SCIENTIFIC AMERICAN SUPPLEMENT

VOLUME LXXX NUMBER 2070 — NEW YORK, SEPTEMBER 4, 1915 — 10 CENTS A COPY $5.00 A YEAR

Fig. 1.—Hammer head crane at Krupp's works, capable of lifting 150 tons, placing engines in German warship Deutschland.

Giant German and Austrian Cranes

Required in Navy Yards for Placing Turrets, Guns and Machinery

By Frank C. Perkins

In the various German and Austrian shipyards, as well as those of other European countries, where large ships are constructed, it is necessary to provide steam and electrically operated floating cranes, hammer cranes and hoists of capacity to correspond with the greatly increased size and weight of the parts that giant modern battleships and cruisers require. The same is true of the entire shipyard equipment, such as the building berths, electrically operated traveling cranes, and wharf cranes, which have to be made more powerful and efficient, for the new demands made upon them. There are now four new 250-ton giant electric cranes either under construction or recently placed in service in the German shipyards.

The use of a floating crane with two hoists of 120 tons each for raising large guns and similar heavy bodies is shown in photograph (Fig. 3), while drawing (Fig. 4) shows details of construction and indicate the method of operation of this giant crane as built by the Prager-Maschinenbau Actien-Gesellschaft of Prague, Austria-Hungary. The greatest hoisting height of this floating crane is 78.74 feet above the water. At 48 feet radius of action it will hoist 120 tons and 90 tons at 60 feet by means of the outer trolley. The main hoist is driven by a two-cylinder steam engine operating at 200 revolutions per minute. Each cylinder of this steam engine has a diameter of 20 inches and a stroke of 20.8 inches.

It is maintained that this great floating crane will raise a load of 30 tons with one trolley at a speed of 14.75 feet per minute and a maximum load of 240 tons with both trolleys in service, at the rate of 2.5 feet per minute. The total width of this floating crane as noted in drawing (Fig. 4) is 75 feet, the three boilers being installed as indicated. The legs of the crane are each 30.34 feet center to center.

The great crane at the Vulcan yards at Stettin is electrically driven throughout, the maximum load of 250 tons being lifted at a distance of 105 feet from the center of the crane, or 74 feet from the edge of the quay wall. The 50-ton trolley is principally used for attaching armor plates and it can handle the full load at a distance of 180 feet from the center. The 5-ton hook of the auxiliary crane has a radius of 33 feet, and can take up loads at 216 feet from the center of the crane, covering an area of 3.3 acres in a full revolution of the big crane. The operator's cabin is about 160 feet above water level and the entire crane is controlled by one man.

It is of interest to note that the floating crane for Wilhelmshaven has a larger outreach and several additional hooks. It can lift the maximum load of 250 tons at a distance of 59 feet from the fender over three sides of the rectangular pontoon. The pontoon has a beam of 100 feet and can carry a deck load of 500 tons. This crane carries a 50-ton hook at the end of the jib, two 125-ton hooks about 40 feet below same, a 20-ton climbing trolley and a 10-ton hook alongside of each one of the two large hooks. The 10-ton hooks are used mainly for handling the chains and slings when attaching and detaching heavy loads to and from the big hooks. Loads of 50 tons can be raised at a clear reach of 130 feet over the fender. It is stated that the hoisting, luffing and revolving motions are driven by direct current electric motors, which receive their current from two generating sets, each driven by a steam turbine located in the pontoon. One set is for reserve. The current for the

(Continued on page 148)

Radiotelephony*

Some of Its Problems and Reasons for Its Slow Progress

By W. C. White, Research Laboratory, General Electric Company

Shortly after radiotelegraphy had become an accomplished fact, radiotelephony was proposed and experiments undertaken along that line. The fact that apparatus was at hand by which the voice could be made to give a variable form of electric current and apparatus by which this form of current could be made to reproduce the original voice made the problem seem simple in comparison with the original development of the telephone.

In order to understand the problems of radiotelephony and why it has made so much slower progress than radiotelegraphy, it is necessary to review some of the principles involved in radiotransmission in general.

Fundamentally, what happens in radiotransmission is that a certain amount of energy is generated and liberated at the transmitter, from which it radiates more or less in every direction, and a very minute portion of it is intercepted at the receiving station where it energizes the receiving apparatus. This is therefore a transfer of energy and as such requires a medium.

It has been shown that light and radio-waves are similar phenomena in this medium which we call the ether. Now, as to how these radio or electromagnetic-waves are set up in the ether, a rough analogy will help to make the theory clear. Imagine a paddle dipped vertically into a body of water; if this is moved very slowly back and forth water will merely flow from the volume in front of the advancing paddle around the edges to the space just vacated. Floating corks arranged in a circle about the paddle and at a radius of several feet away would not show any movement, proving that all the energy used in moving the paddle was expended as friction at its surface or in eddies or currents set up in the immediate vicinity.

Now suppose the frequency of the back and forth motion is increased. Common experience tells us that waves will be set up which become appreciable after a certain frequency of motion has been passed. Bodies floating in the water at a distance will be moved up and down (even against an applied friction) as the waves pass them, showing that in the case of the rapidly swinging paddle its energy is used up in two ways; in the first place, as friction, as already mentioned, and, in the second, by waves which transfer the energy through the medium away from the source until it sets some mass swinging whose friction dissipates the energy transmitted. Naturally, if one wishes to make short length waves a small paddle would be moved rapidly, and for long wave lengths a large paddle moved slowly.

In order for a medium to transfer energy away from a source by wave motion, it must have inertia; and of the tangible mediums with which we are familiar, the less their density the higher the rate of vibration must be before an appreciable portion of energy leaves the source by means of wave-motion radiation.

Returning now to electromagnetic-waves. If a straight conductor in space is carrying an alternating current at 60 cycles frequency, the only loss we could measure would be that due to its resistance. It is true, of course, that if a conductor of a second closed circuit were to parallel the first conductor, a current would be induced in the former which would consume energy. This is due to a magnetic field about the first conductor, which may be said to grow from and collapse upon its source twice each cycle, but never traveling away from it continuously.

If a conductor carries a current at say 100,000 cycles, energy in the form of electromagnetic-waves will leave it and travel away with the velocity of light, and, if these waves intercept another circuit, a current of 100,000 cycles frequency will there be set up. The amplitude of these waves decreases as the distance from the source increases; and experience shows that a certain loss of energy occurs as the waves travel in space, due, undoubtedly, to atmospheric conditions, which loss is termed "absorption."

It is remarkable what good results this method of teaching has produced.

In a latter part of the term the direct-current generator and motor phenomena are illustrated by means of an old-fashioned bipolar shunt wound dynamo which has been fixed for the purpose and provided with a flywheel. This makes possible the illustration of the counter-electromotive force which exists in a running motor. Suppose the dynamo has been connected up at the end of the above described miniature transmission line, and runs as a motor. A set of lamps on the same transmission line shows its bright lights as a result of the power which it takes from the same source. If now the double-pole switch between the binding post and the transmission lines is suddenly opened, the motor, because of the inertia of its flywheel, will become a generator, and the lamps will still show their bright lights, this time, however, taking their power from the dynamo side; for the current on that side is reversed, as is clearly shown by means of an ammeter. The voltage on the line can be measured at the instant that the double-pole switch is opened, which serves to illustrate in a clear and real way the counter-electromotive force which existed an instant before while the dynamo was still running as a motor.

Thus the student becomes familiar with all the secrets of the dynamo. Even this counter-electromotive force, so often the stumbling block to beginners, becomes visible, almost palpable to them, and impresses itself on their minds. The measurements of voltage and currents, in relation to the speeds through which the flywheel passes, are then written down, calculations are made and again experimentally verified, and it is thus that the different phenomena enter into the mind almost without effort; for the student is interested in these different operations from start to finish, and is not tired out by an undue effort of the imagination. The channels between his senses and his mind are wide open, and the knowledge enters without effort.

During the second term of electricity, Swoope's textbook, "Lessons in Practical Electricity," is used. This textbook is rich in material, and in this lies its great merit, for it offers many topics to be treated and talked about in the classroom. It describes many experiments, and to follow these descriptions requires a certain amount of the student's imagination. It is to be noticed again that the student of the engineering school is a high school graduate and has had his imagination trained to a greater extent than has the average apprentice. As the time is limited, considering the large scope of the book, this term is mainly devoted to theory, though here and there concrete illustrations are made if the described experiments of the book do not convey the fact clearly enough to the mind.

The third term of electricity is devoted entirely to experiments and laboratory work. Large direct-current and alternating-current dynamos and the necessary instruments are put into the student's hands, and under the direction of their instructor they make the usual practical tests relating to voltage, speed, load, losses, and efficiency. It is surprising how quickly the students get hold of this term's work and of the right way of doing things. Their enthusiasm and pleasure in the work is very visible in the neatness with which they make up their reports. Some of these are almost pieces of art, so carefully are the sketches drawn and the curves traced.

After this term of heavy practical work, the student goes back again to pure theory. Two terms of advanced electricity along the lines of Franklin & Esty's textbook of electrical engineering now follow. During this time the student has ample occasion to verify and think theoretically over the different points and phenomena which have come up during the former term, and thus the last foundation stone of electrical knowledge is deposited in his brain.

The classroom in which the student gets these advanced courses of electrical engineering is in the laboratory, so that the whole atmosphere is impregnated with the practical developments of the great industry. Dynamos, rheostats, and all kinds of motors look at him from all sides while he ponders over some intricate problem, and like real friends suggest ideas to him. The walls carry charts illustrating such useful rules as the famous Fleming's three-finger rules for motor and generator directions, and the unconscious daily look at these charts produces on the student's mind a lasting impression, in the same way as in daily life the advertising poster impresses the public mind. If there is any formula, any figure, difficult yet useful to remember, there is no better and easier way of mastering it in one's memory than by posting it in some conspicuous place to which the eye is turned every day. These repeated impressions will leave their mark without requiring any acrobatic effort of the brain.

It is not to be inferred from these arguments that there is any theoretical reason why water waves or electromagnetic-waves of very low frequency cannot be produced. For instance, a huge barrier 1,000 miles long moved through an amplitude of, say 1,000 miles, in the middle of the Pacific Ocean with a swing once a day, would set up waves of enormous power, probably causing a tidal flood on the shores of the ocean.

In a similar way, a huge electrical capacity in the transmitting radiating circuit, charged at an enormously high potential, would radiate waves at a frequency of 60 cycles. It is impractical, however, to construct an aerial radiating system of sufficient capacity, and corona losses prevent the utilization of a high enough voltage.

The simplest and most commonly employed method of obtaining high-frequency currents is by spark excitation. A weight suspended by a spring will have a natural period of vibration, depending upon the stiffness of the spring and the mass of the attached body. It will take up this frequency of vibration when struck an upward or downward blow and continue its oscillations for some time. In an analogous way an electrical circuit having inductance and capacity will have a high-frequency electric current set up in it when its circuit is completed by a spark which allows readjustment of the charge stored in it.

As mentioned, a high-frequency current is set up in the circuit of the distant receiver, due to the aerial wires (these intercepting the electromagnetic-waves from the transmitter). As these currents are minute, the most sensitive form of indicator must be employed.

In order to get an idea of the magnitude of the currents and the amount of energy involved, a few quantitative examples will be given. The radiating circuit of a radio-transmitter is said to have a certain number of ohms resistance, which may be defined as that quantity which when multiplied by the square of the current in amperes gives as a product the number of watts dissipated. A large station designed to transmit a distance of 1,000 miles or more may use 75 amperes in a circuit of 8 ohms so-called antenna resistance.

In a receiving station 2,000 miles away, having a resistance of 25 ohms in its receiving circuit and apparatus, a current as high as 50 microamperes may be set up, which means about 6×10^{-8} watts. When we consider the distances, this current seems large; the pointer of the usual type of sensitive, portable, direct-current voltmeter will give about a one millimeter movement with such a value of direct current. It is to be remembered, however, that in the receiver circuit the capacity and inductance are adjusted for resonance for the incoming frequency, so that in order to realize this amount of current in any indicating device, its resistance must be very low.

Now for direct currents the d'Arsonval galvanometer principle, such as employed in most direct-current indicating instruments, is the most practical form of sensitive current indicator. For alternating currents of frequencies of about 150 to 2,000 cycles, the Bell telephone receiver is most sensitive and simple. A good telephone receiver is responsive to one tenth of one microampere alternating current at a frequency of 500 cycles.

The currents induced in the receiving circuit, from a transmitter generating its oscillations by spark discharges as mentioned, consist of groups of very high frequency current coming at intervals determined by the rate of spark discharge.

It is evident, then, that in the receiving circuit some device must be utilized which will respond to the minute high-frequency currents set up, or they must be transformed into a form of current to which a galvanometer or telephone is adapted.

This latter method is most commonly employed, several rectifying devices being available which change the high-frequency groups more or less perfectly into a half-wave alternating current having the same frequency as the spark intervals at the transmitter. Such a form of current will actuate a galvanometer or give response in a telephone, the latter being ordinarily used because of greater convenience and speed of operation. In practice, the sparks at the transmitter are made to occur at rapid and regular intervals, so that a fairly pure musical note is heard in the receiving telephone.

Different spark frequencies will produce corresponding tones in the receiving telephones. This really illustrates the fundamental principle of a radiotelephone transmitter, viz., the radiating of high-frequency electromagnetic-waves in groups corresponding to the tone to be transmitted.

In order that the voice may be reproduced in an ordinary Bell telephone receiver, a current must be passed through its winding which has an alternating-current component corresponding in frequency and wave shape to the fundamental and overtones in the voice, and in amplitude to its loudness.

* Courtesy the *General Electric Review*.

Now, if in a receiving circuit as described a continuous high-frequency current were induced in the aerial circuit, instead of in groups periodically by the spark transmitter, a direct current would flow through the telephone receiver pulsating at a frequency far too high to hear, the effect being identical to that of a continuous current.

The alternating-current component necessary to reproduce speech may be obtained by varying the amplitude of this continuous current at the proper variable rate, which in turn can be accomplished by varying the rate of amplitude change in the high-frequency waves, intercepting and setting up corresponding currents in the receiving aerial.

These various forms of currents can best be made clear by some simple diagrams illustrating the principles involved.

Fig. 1 illustrates a direct current consisting of an alternating current of 1,000 cycles frequency superimposed upon a continuous current. Such a frequency passing through a telephone receiver would produce a high pitched musical tone.

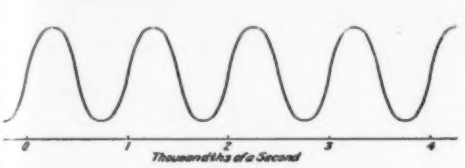


Fig. 1.—A series of direct current waves which are made up to a 1,000-cycle, alternating current and a continuous current.

Fig. 2 illustrates a rectified high-frequency current of 50,000 cycles, the negative half of the wave being suppressed by the rectifying device. Such a form of current passed through a telephone or direct-current instrument will give a response or indication, as if a continuous current were passing whose value is equal to the average of the instantaneous values, or about 32 per cent of the peak value of the rectified wave. This is shown by dotted lines.

Fig. 2.—An illustration of a rectified 50,000-cycle alternating current. The dotted line indicates the value of the instantaneous peak values.

Fig. 3 represents a high-frequency current of 50,000 cycles, varying in amplitude so as to reach a minimum every 0.0005 of a second, or at a rate corresponding to 1,000 cycles per second.

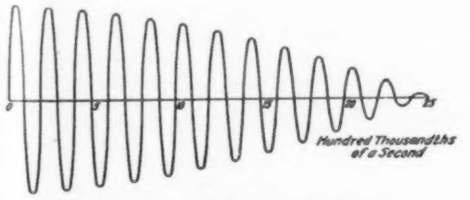


Fig. 3.—A representation of a 50,000 alternating current of varying amplitude.

Such a current, passed through a rectifying device, is shown in Fig. 4, and the dotted line shows the equivalent average current, which is of 1,000 cycles, and produces the effect of such a current in a telephone receiver. A direct current added would make it identical to Fig. 1. A musical tone may thus be produced in the receiving circuit by a periodic variation in the value of the current in the transmitting circuit.

Under actual conditions the variations will follow an irregular curve, due to the overtones and inflections of the voice, and the rectified high-frequency wave form will be complicated by the fact that the rectifying devices used do not rectify perfectly, and because condensers are used to store the energy of succeeding waves so that the high-frequency current does not actually have to pass through the telephone windings.

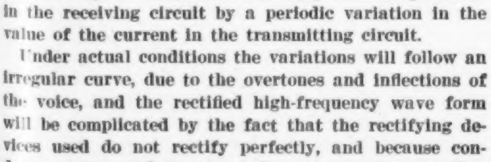


Fig. 4.—The formation which the wave shown in Fig. 3 assumes when rectified. The dotted line is of an equivalent 1,000-cycle current.

The usual form of radiotelegraphic receiving apparatus is therefore suitable for telephony, so that the modifications necessary are in the transmitting equipment.

The first feature is that the transmitting station must be capable of generating high-frequency currents and radiating them so that the currents induced in the receiving apparatus when rectified will cause no disturbing noise in the telephone receiver. This may be done in two ways, either by a continuous high-frequency wave, or by one generated by the spark system described, the sparks, however, occurring one after the other so rapidly that their frequency is above the audible range where the telephone and ear are not sensitive and any resultant tone would not interfere with the reception of speech.

So far, the former method has proved the more practical, and the continuous high-frequency currents are generated either by an alternator of special design, or by some form of high-voltage direct-current arc shunted by a capacity and inductance. The Poulsen arc-generator is an apparatus of this type.

The second important feature in the transmitter is some method by which the amplitude of the high-frequency current may be controlled and modulated by the voice so that the amplitude of the radiated waves follows closely every variation in the voice. Since the voice in speech is a complex set of sound waves varying continually in frequency and amplitude, and containing overtones, it will be realized that it is very difficult to modulate a current of, say, even 10 to 20 amperes through a wide variation and preserve at the same time the correct relative intensity of the different voice frequencies involved in order that the articulations at the receiving station are good.

This matter of sufficient energy control is the one big problem in long-distance radiotelephony, and is the factor which has made it impossible so far to attain any thing like the distance range that is accomplished in radiotelegraphy.

A great deal of work has been done by different investigators on the improvement of microphone transmitters which will handle heavy currents and give good articulations. The ordinary microphone transmitter, such as is in use on all telephones, operates with about a quarter of an ampere and about 10 volts across it. This means a control in energy variation of but a few watts. Modifications in such a type of microphone transmitter may be made so that it will control several amperes, and special microphones have been built to handle considerably more current, but so far none have been perfected to control the large currents such as are used in high-powered radio-stations.

There are two promising fields for radiotelephony. The first is for long distance, where wire telephony at present is impossible over submarine cables, and expensive on land. The other is for relatively short distance, for use between ships and from shore to nearby ships; the latter being used in connection with the land lines, so that conversation may be had with vessels not too far from land with the same ease that we now talk from one city to another.

For the realization of this latter application several additional difficulties remain to be overcome. The great difference between transmitted energy and received energy prohibits the simultaneous use of sending and receiving apparatus, so that some form of throw-over device has been found necessary to change connections to either one or the other. Although the high-frequency alternator and the Poulsen arc give good results, both require more or less attention and are not suitable for small ship installations.

For use in connection with existing land lines, the problem of control is even more difficult, as here we have only minute currents to effect the control of a large amount of energy.

It is doubtful whether radiotelephony will ever supersede our present wire system on short distances over land, but it will undoubtedly be of immense value in fields where the wire telephone is impracticable.

Outline of the Coal Tar Chemical Industry

When coal undergoes destructive distillation in coke ovens or gas retorts, the average products are as follows: Coke, 72 per cent; gas, 22 per cent; tar, 6 per cent.

The tar contains some 155 different chemical compounds, none of which are dyes. Ten of these substances are utilized in the manufacture of dyestuffs. They are: Benzol, toluol, xylol, phenol, cresol, naphthalene, anthracene, methyl anthracene, phenanthrene, and carbazol. The first three are present to a considerable extent in the crude gas, given off on distillation. Only by the use of specially designed purifiers can they be removed or separated.

The 10 substances enumerated form 6 to 12 per cent of the coal tar, the amounts varying according to the character of distillation. The average yield is about as follows:

Substances.	Percentage of tar.	Percentage of coal.
Benzol, toluol, xylol	1.75	0.115
Phenol, cresol	0.25	0.015
Naphthalene	5.95	0.357
Anthracene and remaining compounds	0.20	0.012

These 10 primary, or crude, coal-tar products are separated from one another, and from the great variety of carbon compounds accompanying them in the tar, by fractional distillation. This operation is carried on in the tar distilleries, which supply likewise pitch, creosote oil, naphtha, and other crude mixtures of coal-tar constitutents.

From the 10 primary "crudes," chemical works of a high character prepare nearly 300 so-called "intermediates," compounds that are not dyes, but which are susceptible by direct reactions of being transformed into coloring matters. A number of these intermediates serve also in the manufacture of medicinal preparations, photographic chemicals, etc. Leading intermediates are aniline oil and salts, pure aniline and toluidine, nitrobenzol, naphthol, phthalic acid, salicylic acid, resorcin, anthraquinone, etc. These intermediate products serve as the raw material for the manufacture of dyes. From them he makes over 900 different dyestuffs now currently sold in the world's markets.

In a general way it may be stated that the average intermediate sells for five times as much as the average crude coal-tar derivative, and the average finished dye for ten times as much, a very material enhancement in value.

The number of intermediates now in active use does not exhaust the possibilities in this class. Many hundreds more are known to the chemist and can be employed in dye manufacture. Less than 300 have been found sufficient to meet the needs of makers and to combine technical with economic advantages.

The same may be said of finished dyes. The number of possible distinct dyestuffs covered by patent specifications up to the present would run into the millions. Of the many possibilities only 900 have won a recognized position, and of these only 400 are of very extended use.

It is doubtful whether many additions of value will be made to the current list of artificial dyestuffs in the immediate future. The field has been worked most thoroughly by color chemists. During the past decade only a single new class of dyes has been discovered and placed on the market.

Briefly summarizing the coal-tar dyestuff industry, the following features are obviously essential to success:

The presence of an ample supply of coal.

The extensive use of this coal for gas and coke manufacture.

The use of a plant that allows the recovery of the volatile organic compounds formed during destructive distillation.

The industrial treatment of the tar produced, so as to separate and furnish in a fairly pure form 10 crude substances.

The existence of well-equipped chemical works, able to transform the 10 crudes into nearly 300 more complex intermediate compounds.

The existence of highly organized works for manufacturing from these intermediates some 900 different dyestuffs.

An ample and sure supply of a variety of acids and heavy chemicals for effecting the numerous transformations.

A relatively large number of chemists who have enjoyed un'versity training.—*Report of Bureau of Foreign and Domestic Commerce, U. S. Department of Commerce.*

Wages in the German Factories

The participation of labor in the cost of finished dyes is not high. It ranges from 10 to 15 per cent, and is usually nearer the lower figure. There has been, however, a steady increase in the average wage rate of late years. The average daily wage in Germany for all labor—boys, and common and skilled labor—was $0.65 in 1886. In 1908 it had reached $1.14, an increase of 75 per cent. In 1906 the average daily wage in the Badische works for a 10-hour day was $1.04. To the normal wage should be added the contribution by employers to the State old-age, accident, and sick funds, bonuses gained by many workmen, and the gifts for general welfare. In the case of the Badische this gift was $750,000 in 1908. Including these various items, it may be assumed that the prevalent adult daily wage in the dyestuff works is now about $1.80, as far as the actual outlay by the employers is concerned.

A large item in the cost of production is due to the salaries of well-trained, competent chemists and engineers, who supervise every step of the multitudinous processes. Thus, the "Badische" employs 30 well-equipped chemists—university graduates—in the research laboratory alone, quite apart from the manufacturing staff.—*Report of Bureau of Foreign and Domestic Commerce.*

Fig. 2.—Large floating crane at Germania Werft, Kiel-Gaarden.

Giant German and Austrian Cranes

(Continued from first page)

electric light service and for exciting the motors is furnished by a separate steam driven unit, and provision is made that this current can be supplied from land also. The entire controlling apparatus is placed in the operator's cabin below the pivot of the jib, about 65 feet above the water level. The machinery of the crane is attached to the lower section of the revolving part of the crane structure. This German warship floating crane is self propelled by two screws, each driven by a 500 horse-power triple expansion steam engine.

The great 150-ton hammer head warship wharf crane of the Fried-Krupp Actien Gesellschaft or Germania werft at Kiel Gaarden, Germany, may be seen in the accompanying illustration (Fig. 1) installing one of the large steam engines in the German battleship "Deutschland." There is also in service there a large floating crane as shown in Fig. 2 and several electric traveling hoists in this great shipyard. The floating crane will raise loads of 6,614 pounds to a height of 95 feet, the outreach over the pontoon being 42.29 feet.

It will be seen that cranes of 150 tons capacity, which were considered amply large enough a few years ago, prove insufficient for handling heavy machinery, parts and turrets which enter into the construction of modern ships. Also the outreaches of these cranes have to be increased, owing to the increase in the width of the vessels. Under these conditions the leading German shipyards found it necessary to add to their equipment cranes of 250 tons capacity.

There is a new 250-ton wharf crane at Hamburg. The Deutsche Maschinenfabruk at Duisburg, Germany, has under construction a 250-ton floating crane, while there is also a new 250-ton revolving floating crane at the Imperial Navy Yard at Wilhelmshaven. A 250-ton wharf crane of the hammer type has also been provided for the shipyard Schickau at Danzig, Germany.

It may be stated that the 250-ton wharf crane for the Schickau shipyard was originally ordered for a capacity of 200 tons, but during construction it was decided to increase the capacity to 250 tons. It is equipped with one 250-ton trolley and one 50-ton trolley, both running on the same track inside of the long arm of the jib. A revolving traveling crane runs on the top chord over the entire length of the jib and has two hooks of 20 and 5 tons capacity respectively. The top chord of the jib is 187 feet above the wharf and its length is 320 feet.

Our Unpreparedness Against Military Devastation

The National Safety Above Either Sectional or Political Interests

By Henry A. Wise Wood

It would be remiss did I not spend the first of the few minutes allotted me in expressing for the nine organizations, represented here, their deep gratitude for the opportunity afforded by your invitation, of setting before you their anxieties over the grave condition of our national defenses. I need not say that in coming to you, through me, they are conscious that they are being heard by those who have been chosen, by the forty-eight commonwealths, which make up our common country, as the men who, by character, wisdom and training, are the most able among their citizens to discharge the heavy responsibilities attaching to their protection and governance. Nor is this all; for those who compose these organizations, in untroubled times of all shades of political faith, have sunk their political differences, and given me instructions to appeal to you as an American representing Americans, who in this hour of perplexity have at heart neither sectional nor political interests, but only the national safety.

Thus, I come to you with hands that are clean of politics, with no criticism of parties or of men, intent solely upon saying that a large and intelligent body of our people are so thoroughly aroused over the use that is being made of the armaments of Europe, and of the threat against our security which that use implies, that they have determined, at whatever cost, to place this land beyond the reach of military devastation. In common with you and with all citizens, whose anxieties they believe they correctly interpret, those who compose these bodies for which I speak abhor war, and detest that spirit which would make of military domination the chief object of a nation's thought. Also, they deny the validity of the doctrine that would make of the civilian the pawn of a military caste, and assert that a free civil life should be the chief aim of national existence.

The soldier who carries a weapon for purposes of aggression is in their eyes, as in the eyes of every lover of Peace, an unspeakably iniquitous product of government, whom they will neither create for themselves, nor permit in the interest of others to set his foot upon this soil, wetted in the freeing by the blood of your forebears, of my forebears, and of their forebears. Neither now nor ever can the specter of militarism, of the control of our national life by a despotic military caste, rear itself in this democratic land. On this national policy stand we all of us, firm in the belief that however high the armed dyke which we must now rear to protect our shores from the threatening flood of devastating war, that dyke ever shall remain a bulwark of personal liberty, and never become the wall of a barracks, in which its creators may bind the populace to the wheels of the chariot of aggression, to be driven into other lands. Therefore, this great movement which we represent is not open to the charge, which the timid are inclined to make, that it seeks to saddle our people with a form—with any form—of military despotism.

Recently, I have come here through some of the most beautiful country that man ever has tilled and woman carpeted with flowers. There were fields of grain that beat like the waves of a golden sea against green islands of trees hung with gems of fruit. There were winding roads of exquisite smoothness, swift ribbons of friendship which bind together in neighborly contentment the homes of the rich and the less rich alike. There were factories throbbing with work. There were white churches, there were libraries, there were playgrounds. And, gentlemen, filling all of these, there were people—men, women, children—happy, thoughtless, and carefree. In all of my journey, I do not remember having seen a rough incident of life, nor even a policeman to remind me that there still remains in the world the need for force. And I thought how good is civil life; how precious the

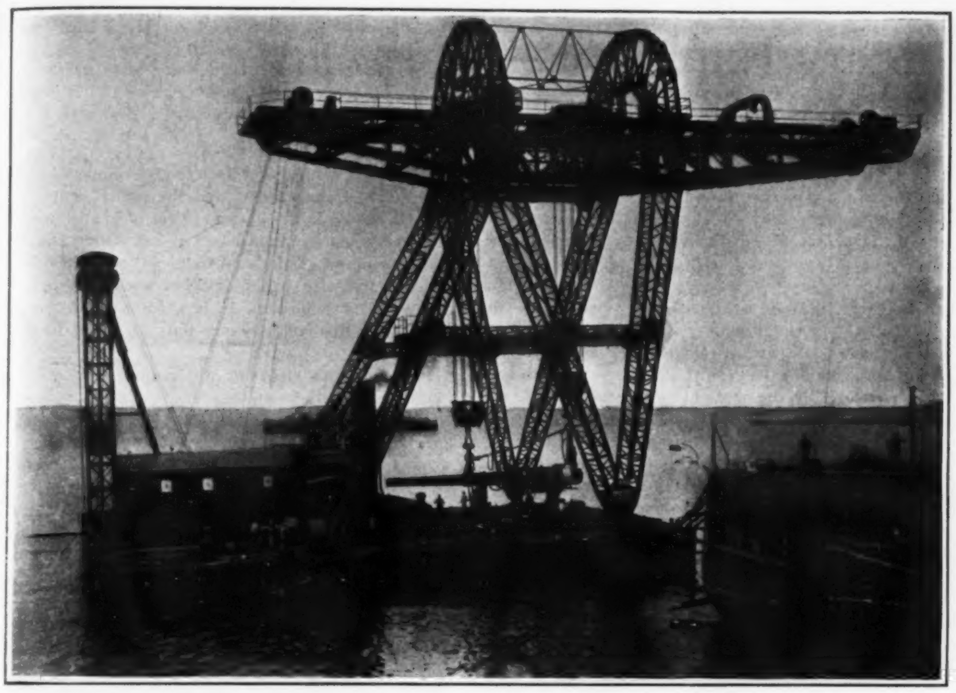


Fig. 3.—Floating crane, built at Prague, with two 120-ton hoists.

freedom to go or to come, to work or to play, to think or to speak, as one's own soul dictates. And how sweet the security of life—the peace with which the mother sees her children go forth for the day, the confidence with which she awaits their return at evening.

Then I thought of the beautiful plains of Belgium, as I had seen them last, of the children at play, and the women and men at work in their fancied security, and the gem-like houses in which even the poor resided. Then the present came over me with horror; I wondered where now the children, and the men and women I had seen, and what of the future of those who are left. Then I thought of the horrid cause which had made it necessary, and of you, gentlemen, who wear the heavy robes of responsibility, and who are charged with the lives and happiness of those who have placed themselves in your keeping.

I found myself wondering if some of us are not yet unaware of the full meaning of the change which has come over the world, of what it portends, and of the hideous possibilities for us which it contains. I wondered if some might not still be blinded by the few fragments which remain of our belief that all controversies may be settled without war, and if they know how thoroughly that belief, and our overconfidence in the integrity of the world, has thrown our means of defense into decay, and left us open to the marauder.

These things I now say frankly, because I am exceeding fearful. I know how devoutly you wish that we be left at peace, to work out the huge, benign problems of a healthier existence, in the solution of which we are engaged. But I am fearful lest many of us should misjudge the means by which that peace may be secured, and thereby permit our very love for peace to imperil the preservation of it. I confess to being a hater of war, a passionate advocate of the maintenance of peace, but I realize that peace to be had must sometimes be fought for, that to be preserved it must be protected, and that to be protected it must be surrounded by impregnable barriers. In the name of all that is dear to us, I now ask for those barriers, and beg that with all the weight of your patriotism you will labor with us to surround our common country with such barriers, by sea and by land, as shall place wholly beyond the possibility of enactment, upon your soil and mine, among your people and my own, the hideous scenes of carnage and rape, that have made the face of our clean and chivalrous American manhood hot with anger and shame.

I am in no sense an alarmist; I am merely looking the facts of life, as they are to-day, straight in the face. The things I am pointing out are not fancies, they are dreadful realities. They are not remote, they are but a week's time away, by transport travel. They are not isolated, they are general and widespread, and they are not accidental occurrences, but have become the established procedure of modern warfare. There is a moral pestilence abroad, a pestilence we thought the physicians of diplomacy had eradicated forever. We now see that they hadn't; that instead it has suddenly broken out afresh, to sweep Europe with such virulence as the world never has seen. *That* was one of our misconceptions. What shall we do? Permit this pestilence to flow over our coasts, and devastate our land, as it has Europe? Or shall we establish a quarantine, and place ourselves in position to repel it, at our borders?

We were taught that our seas would insulate us against this pestilence; that we might rest secure behind their seeming vast expanse. But we find, instead, that they are its swiftest highway, that over them it may pass countless forces of destruction, with a celerity never before known to the passage of armies. *That* was *another* of our misconceptions.

But a few days since I obtained the information that in the archives at Washington there is a document which sets forth the celerity with which these very seas may suddenly be used for an attack upon us. According to its contents, which gave the number of men each of several nations could land upon our shores within a given period of time, it lay within the power of one of those nations to set down upon our Atlantic coasts, in 46 days, over 750,000 men, with sufficient artillery, ammunition, and supplies to last them for three months. And on our Pacific coast, it was stated, in 61 days there could be landed approximately 350,000 men, with supplies and weapons.

Again, a friend informs me that he was recently looking over Fort Delaware, guarding the approaches to Philadelphia, which contains four 12-inch disappearing guns, and the necessary power plant and machinery for their operation, when there was turned out for ininspection its garrison—its garrison of thirteen men. Gentlemen, here are two wholly typical pictures. I have set them side by side, not in criticism of the wisdom of old Congresses, which are past and gone, but to illustrate the preparedness of Europe, and the unpreparedness of the United States.

Now, what are we going to do about it? We can take *no* measures whatever, or we can take half measures, or we can take *whole* measures, for our protection. Were the pestilence cholera, which of the three would we choose, do you think? One need scarcely ask that. And would the cost make us hesitate? Hardly. Is war, then, less of a scourge, that we should hesitate over making its incoming impossible? Had Belgium, or France, been given the choice of these scourges, can we doubt what that choice would have been? If *we* hesitate at whole measures, because of their cost, is it not because we have failed to value our male youth and our maidenhood, our homes and our freedom, and to put these vital things into the scales against money?

But what are *whole* measures? Neither you know, nor I know. We are but civilians, amateurs, looking on a serious game whose problems long have passed beyond the grasp of any but trained minds. Those of you, who are jurists, have a time-honored saying that he who is his own lawyer has a fool for his client. To this I should like to add another, that the civilian who is his own military expert has an ass to defend. There are many of us in this plight—and some contribute to the *Congressional Record.*

Fortunately, it is not necessary for us to say what are whole measures. We need only say we want them to be taken, and then to turn the matter over to those professional men whom, with infinite care and at great expense, we have trained, and especially retain, for the solution of our naval and military problems. Now it is just at this crisis that you can make the great weight of your influence felt on behalf of an adequate national defense. You can insist that the policy of neglect and suppression, which has been pursued by Congress in dealing with our naval and military advisers, shall cease, and that they and their matured plans shall be treated with consideration and respect. If you would know at whose doors the deplorable state of our defenses should properly be laid, and the brilliant work that our officers have done to establish them, work which never has seen the light of day, you need only search committee and departmental pigeon-holes, whereinto the life's work of these men has been thrust and forgotten.

In this emergency we need no new men, we need few, if any, new plans, but we need to resurrect from their dusty graves the recommendations of our General Staff and our Naval Board, and breathe into them life. Then, and then only, may we again go about our affairs, confident in our ability to resist successfully the attack of any nation, however suddenly it may come upon us. To be able so to resist is all we ask, but the ability to do it, and nothing less, we believe we are entitled to demand at the hands of our Government, and for your aid in this patriotic work we beg, with all the earnestness of men who believe their country to be in jeopardy.

Finally, for but a word more shall I ask for indulgence.

I speak for the Navy League, that veteran patriotic society, which has labored so long and lovingly to build up our navy, and to give us again our place on the seas as a merchant nation; for the Army League, which has striven so well to testify to the civilian's appreciation of the patience and untiring devotion which our army has shown under the discouraging circumstances which have hampered its work; for the National Security League, now a great power, which is arousing our country to a sense of its defenselessness, and the necessity for prompt precautionary action; for that extraordinary institution, the American Legion, which has enrolled close to a hundred thousand men, who have agreed to serve the country in their respective capacities, in the event of need; for the Red Cross, that beloved Samaritan among organizations; for the Aero Club of America, which first perceived the value of aircraft, and has striven so untiringly to place aeronautics upon a safe and practicable basis, and which even now, while the Government lags, is fitting out the National Guard with aeroplanes; for the Automobile Club of America, patriotically engaged in solving problems of transport; for the Institute of Radio Engineers, composed of the men who link ship to ship and all to shore in a community of intelligence; and for the United States Power Boat Squadron, organized to supply, in the event of need, those smaller but vital auxiliaries, so necessary to defensive operations.

According to a Paris daily paper, at the beginning of the war, the fuse of the shell of the German field gun was made entirely of copper and weighed close on two pounds. Gradually the copper was replaced in part by aluminium, and in February, the French in Champagne began to find German shells of which the fuses were of aluminium with an iron cap. These weighed only just over 11 ounces.

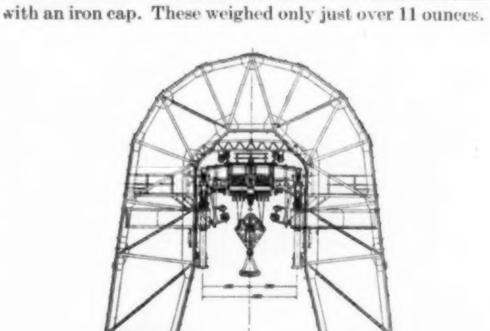


Fig. 4.—Transverse elevation of crane shown in Fig. 3.

Military Explosives—I

Their Chemistry, Preparation and Action

The importance of artillery in the present European struggle has quickened public interest in the question of explosives. It was by the aid of huge shells that the Germans won their successes at the beginning of the struggle. The use of such explosives is a development of recent years; during the war of 1870 between France and Germany ordinary gunpowder in various forms was the main dependence for all arms. Not long ago the German journal *Prometheus* contained an interesting description by Dr. Krumbhaar of the explosives used in warfare, from which account the present article is taken.

For nearly a hundred years, says our author, the chemists have been busy constructing new, complicated substances out of a few simple elements. Up to now 150,000 chemical products have been made and new ones are being added daily. The chemists test these compounds in every way; they crystallize, distill, sublimate, dissolve, heat and ignite them. They also experiment to see whether the new compound may prove to contain a medicinal drug, a dye, an explosive, antiseptic, etc. Among the enormous number of chemical compounds which have been made it was natural that bodies should be found which would decompose explosively when struck, rubbed against, or suddenly heated and ignited. As long ago as 1846 Schönbein in treating cotton with nitric acid obtained a very explosive substance which he called guncotton. It was believed that the powder of the future had been discovered and imagination ran riot over its supposed uses. At first the right way of controlling the latent power of guncotton was not known and horrible accidents occurred. It was not until 1886 that it was gelatinated and thus made suitable for use in weapons and for the manufacture of smokeless powder. Another substance of much importance in the development of explosives is nitroglycerine, discovered by a pupil of Liebig, an Italian named Sobrero. Nobel in 1863 was the first to manufacture it, but in its actual use he encountered many difficulties until he took infusorial earth as an absorbent for the blasting-oil, as the old chemists called it, and thus produced dynamite. In 1888 nitroglycerine was first used in the manufacture of powder, a method of combining it with guncotton having been discovered. Since then a long list of explosives has been chemically produced, among them the aromatic nitro-compounds, which have proved so useful for military purposes. Improvement in the preparation of primings has made it possible to employ substances for explosives that were formerly regarded as harmless and used only as dyes or disinfectants.

The word explosion is used to indicate a great variety of processes, but an actual explosion has among its characteristics a bright blaze and flash, a loud detonation with a widely extended concussion of the air, and, in addition, various mechanical effects. If the explosion is caused by the firing of small-arms or cannon the shot is hurled out, if by the bursting of a shell the covering of the projectile is demolished, if by the blasting of rock the fragments are thrown to a distance. All these phenomena are conditioned on the instantaneous decomposition of the explosion which is started by the ignition. A sharp rise of temperature, shown by the quick blaze, follows, while at the same time great volumes of gas are formed that suddenly push the air aside and thus cause the report and concussion. The instantaneous rise of temperature, together with the appearance of the large bulk of gas in the inclosed charging chamber, causes a violent increase of pressure which is the source of the manifestation of energy by the explosive. Compressed gases contain enormous force, especially when the pressure is high, a force which has been estimated in explosives at 10,000 atmospheres. Gases only slightly compressed can produce powerful effects; for instance, should an iron flask containing compressed oxygen fall and the fastening break off, the valve will fly out like a shot and can go straight through a thick brick wall. Yet this is the effect of little more than 100 atmospheres. On a smaller scale the force of compressed gas is shown by the popping of a champagne cork.

Chemically considered explosives are unstable bodies with a tendency under any shock to speedy conversion into stable gaseous compounds. It must be remembered that these explosives have something unnatural in them, for nature does nothing by jerks, and are properly synthetic products of organic chemistry.

Atoms of carbon arranged in series or closed rings, and atoms of hydrogen, oxygen and nitrogen are combined in the most varied ways by the wonderful methods of chemistry. It is not surprising that in these combinations forms appear the organization of which is purely artificial, so that at the slightest external shock the whole structure falls to pieces.

The heat generated by decomposition is an important item in the extent of an explosive effect. All chemical processes are hastened by increase of temperature; for instance, sugar dissolves more quickly in hot water than in cold, potatoes are cooked through in boiling water, but not in water merely warm. Every increase of 10 degrees of temperature doubles the velocity. The velocity being cumulative the whole process is hastened; heat is released at the moment of decomposition, this heat hastens the process of decomposition, whereby the amount of nascent heat is increased, etc.

The rise of temperature besides quickening the reaction causes a decided increase of pressure in the gas generated; for all gas expands in a rising temperature; so a bottle of champagne has to be kept cool in storage for fear of bursting. The amount of heat generated by explosions has been experimentally measured by the calorimeter and has been found not to be very great. Still the temperature rises very high, because the heat is generated so rapidly that it cannot in reality be carried off.

"The second important factor in an explosive effect," continues Dr. Krumbhaar, "is the volume of gas generated and the increase of pressure conditioned on this. Generation of gas is essential to an explosion. There are chemical reactions which proceed rapidly under the generation of heat, but which do not generate gas and are, therefore, not explosive. The amount of gas varies in the different explosives; the volume, though, is many thousand times larger than that of the solid substance. It is a general law, that bodies in a gaseous form occupy a much larger space than in a solid form. The greater the amount of gas the higher the pressure developed.

In order to obtain an increase of pressure in explosive processes, it is necessary for the proceeding to take place in an inclosed space; if the gases can flow off easily no trace of increase of pressure is found. In fire-arms the explosion takes place at the breech of the barrel or tube, the highly heated volume of gas thereby generated driving out the shot. In shells the charge explodes within the cavity of the projectile, and by its pressure tears apart the steel casing.

The density of the charge is also of importance for the pressure caused by the explosion, that is, the ratio of the space occupied by the charge to the volume at disposal for the explosion. The greater the density of the explosive charge the greater the pressure; if the substance explodes in its own volume, that is, if it fills the entire charging chamber, pressures are produced up to 10,000 kilogrammes per square centimeter. When, therefore, forcible effects are required the charging chamber is filled as fully as possible with the explosive."

The increase of pressure is not, however, the only characteristic of the course of an explosion. Another essential is the velocity with which this increase of pressure is produced. It was soon discovered that considerable differences existed between the various substances. These differences have their origin in the velocity of decomposition, of the propagation of disintegration within the substance, and in the velocity of the rise of pressure. Although all explosive processes take place with extreme rapidity, yet in practical use clearly seen differences appear. Substances instantaneously decomposed, in which the pressure speedily rises to a maximum, are called high explosives; substances in which decomposition takes place more slowly and with a gradual rise of pressure are called low explosives. High explosives crumble rock to powder in blasting, low explosives break the rock into large pieces.

The division of explosives into two classes is of much importance for military purposes. Only substances which are low explosives are suitable for driving shot; high explosives explode so violently that they destroy the weapons themselves before the shot can be expelled, yet these latter explosives make an excellent charge for shells and mines. Military authorities divide explosives according to the "brisance," or velocity of the blow given by an explosive, into propellants, and disruptives.

The highest pressure is produced only gradually in the propellant; consequently, there is time to transmit the force developed to the shot. The effects of the pressure are far beyond those of ordinary gunpowder, require guns more capable of resistance, and thus have had a transforming influence upon the whole science of arms.

The disruptives decompose with instantaneous violence, shown by a detonation. The pressure does not rise steadily, but is at once at its maximum. On account of the enormous velocity of decomposition escape of pressure is impossible, and the entire vicinity is destroyed, which is the desired effect of bombs and shells. The enormous dynamic effect is not solely conditioned upon the speed of the conversion; it also depends upon the velocity with which ignition within the explosive, the wave of explosion, is propagated. Measurements show that this velocity amounts to 8,000 meters per second.

There are no clear-cut distinctions between propellants and disruptives; they express various degrees of the velocity of decomposition. It is now possible to regulate at will the velocity of the blow of various explosives by changing the external form, the density, and by several other factors, so that disruptives may be turned into propellants.

The artilleryman with a short jerk pulls the lanyard toward himself, the charge detonates with a loud crack and drives the shot like lightning out of the tube of the gun. The simple manipulation causes a quick and easy ignition; the present charges could not be ignited by the slow-match of old times. On account of the speed of firing the soldier has not time for this; it would, moreover, be a dangerous beginning owing to the dynamic force of modern powders.

The ignition can take place in various ways. If the explosive is made intensely hot at one spot, or if it comes into contact with a flame, the temperature of ignition is quickly reached and decomposition begins. Substances containing impurities that arise from internal decomposition have a low fulminating temperature and, therefore, explode more easily than pure explosives; for example, badly washed guncotton is very uncertain. The degree of temperature at which explosion takes place serves as a test of durability. Ignition by flame is made use of in primers by adding a combustible substance to the fulminating mercury.

"All explosives," says our author further, "are sensitive to a blow, friction, or pressure. If any substance of an explosive nature is rubbed in a porcelain mortar, or if a small amount of it is struck with a hammer, the substance detonates with great force, as many an unsuspicious experimenter has discovered to his cost. The little toy pistols make use of the detonating force of fulminating mercury, the same substance that is exploded in the primer by the blow of the firing pin of a rifle or cannon. It is easy to understand the sensitiveness to blow and friction, when it is recalled that explosives are unstable bodies. The very slightest jar causes some compounds to give way."

When the fulminating mercury of the detonator or cap explodes the ignition is transmitted apparently to the entire charge of powder or explosive. The deflagration is of much less importance than the high pressure that at once appears and is propagated as an impact wave from the mercury into the charge. Such a sudden pressure starts the decomposition of the explosive as if it were the blow of a hammer; it is called initial shock. It can be very small, for it suffices if ignition is caused at one spot by the sudden pressure. Moreover, the initial shock is much more effective than blow and friction; it causes the explosion of substances that were not supposed to have explosive qualities. The development of the initial ignition has therefore greatly aided the technics of explosives and arms.

All explosives do not act alike under ignition; some are easily detonated, others are more difficult to affect; they vary in sensitiveness, as the experts say. This is best shown in the sensitiveness to friction and blow. The sensitiveness has been so carefully measured in the various substances that the exact weight of a hammer necessary to cause the explosion of a known mixture, when the hammer falls from a defined height, has been determined. By far the most explosive primer is fulminating mercury. The three classes of explosives used in armies to-day are propellants, disruptives, and igniting agents.

The propellants have relatively, but moderate sensitiveness and slight velocity of decomposition; among them are ordinary powder and smokeless powders.

The disruptives are not remarkably sensitive, but they detonate with great rapidity; among them are dynamite, picric acid, and the aromatic nitro-compounds.

The igniting agents are distinguished by great sensitiveness and high velocity of detonation; the most important is fulminating mercury.

The propellants, used for driving shot, are worked up into various kinds of powder. In order to make a suitable powder of this kind the explosive must not be instantaneously converted into gas, for the gas pressure

must reach its maximum gradually. In order to have the explosion follow the desired course the powders are pressed, melted, and gelatinated to a determined density and surface. They receive suitable external form by being cut into strips, cylinders, tubes, etc., or they are mixed in a finely divided state with other explosives and inert substances.

Gunpowder has been known in Europe for some five hundred years. Since the beginning of the fifteenth century it was generally and exclusively used until not so many years ago modern chemistry reduced it to a subordinate position.

In the five hundred years of its sway but few changes were made in the composition of gunpowder, which is a mixture of potassium nitrate, charcoal, and sulphur, the potassium nitrate being by far the largest ingredient. In the course of time it was seen that the sulphur caused the oppressive smoke, and the attempt was made to get rid of this annoyance by reducing the amount of sulphur, but no success was attained. The advance in the building of fortifications and in armor-plating created a demand for a stronger powder and one more uniform in its effects. This demand was met by giving the powder special pressing and form, and the results were mammoth powder, formerly well-known, prismatic powder, and the brown or cocoa powder. With these products the era of ordinary gunpowder may be said to have closed during the eighties of the last century.

At the present day gunpowder is ground very fine and the materials are thoroughly mixed, for it has been found that substances have more effect upon one another the more finely and evenly they are divided. The resulting meal-like powder is pressed and granulated by various processes, and afterward sieved, smoothed and polished.

A little more than 40 per cent of gas is generated in the combustion of black gunpowder; the solid products of decomposition form a fine dust and spread as a disagreeable smoke. This smoke hides the surroundings, preventing rapid firing, and it was in the endeavor to do away with these objections that smokeless powder was invented. Smokeless powder met the long expressed desire for flatter trajectory, a wish which could not be met by ordinary powder without causing an undue recoil of the weapon.

Guncotton, or nitrocellulose, is the basis of modern powders. It took forty years to discover the right way of making a powder suitable for war from it, for in storage it was exceedingly unstable, often decomposing unexpectedly, and thus causing great damage. At first, nitrocellulose exploded in the various arms with such violence that these weapons themselves blew up before the shot had been driven out. Persistent research led to the overcoming of this troublesome characteristic; processes for washing and purifying the cotton were found, also ways of adding stabilizers to make its storage safe; further, methods of gelatination were discovered, by which the velocity of combustion could be regulated at will. The gelatination rests on the ability of certain solvents to destroy the fibrous structure of guncotton and to cause it to swell into a homogeneous mass; among such agents is nitroglycerine which Nobel introduced into the manufacture of powder. At the present day smokeless powders are divided into two classes: pure nitrocellulose powders and nitrocellulose-nitroglycerine powders; and their velocities of decomposition can be varied within wide limits, thus permitting the manufacture of a suitable powder for every form of arms.

Nitrocellulose is not made of ordinary, expensive cotton, but of spinning-mill waste, which consists largely of cellulose. The waste is carefully freed from dirt, fat, and inorganic salts, and separated by machinery. The nitrating process by which it is converted into nitrocellulose is carried out in large vats in which the cellulose is treated under a changing temperature with a mixture of nitric and sulphuric acids, to which various quantities of water are added. After nitration the acidified mixture is whirled in a centrifugal machine, and the product is thoroughly washed several times with cold and warm water, and is also ground finer under water. The aim of the process is to remove unstable impurities which can give rise to dangerous spontaneous decomposition. Nitrocellulose after it is freed from water is harmless; it still, though, contains 33 per cent of water, which under pressure of a thousand atmospheres may be finally reduced to 10 per cent.

Guncotton and collodion cotton are distinguished from each other by the degree of nitration; the former, a highly nitrated product is insoluble in ether-alcohol, the latter which is less nitrated is soluble in the mixture. In other organic solvents, as acetone, acetic ether, etc., both cottons swell into gelatine. The gelatination of nitrocellulose opens the way for its preparation as gunpowder.

Guncotton does not differ in outward appearance from ordinary cotton; in a loose state it burns about 300 times as quickly as black gunpowder; gelatination, reducing this rapidity of combustion, is brought about by ether-alcohol. The wet cotton must first be freed from water, and as drying by heat is dangerous it is treated with alcohol in centrifugal machines. The extraction of the alcohol is at the same time a process of stabilization, as in this way the cotton is cleansed from the residual impurities. The guncotton, still moist with alcohol, and with an admixture of ether, is kneaded in an apparatus similar to the kneading machines of bakeries until the fibrous structure of the cotton is gone and a uniform, plastic mass appears. During the kneading process stabilizers are added, as diphenylamine, or substances that influence the rate of combustion, as camphor. The finished composition, plastic, homogeneous, opaque, is squirted through nozzles into cords, or rolled into plates, or cutting and stamping machines give the desired form, which can be of many kinds, as flakes, cubes, rods, tubes, cylinders, ribbons, cord, star-form, etc. A slight drying causes the solvent to escape from the compressed powder, which is then polished with the aid of graphite. The graphite is added to prevent electrical phenomena when the powder is handled, for in changing a filling, packing, or weighing the ammunition a spark could very easily produce a dangerous ignition.

In addition to the pure nitrocellulose powders, those containing nitroglycerine are important factors in war. As in the case of nitrocellulose the harmless glycerine, so commonly used in medicines, produces a violent explosive when combined with nitric and sulphuric acids. The manufacture is dangerous to those engaged in it, and great precautions must be taken to avoid accidents, the temperature especially being carefully watched. Should the thermometer rise above the permitted degree the whole reaction is run into a large, sunken water tank. The product of the nitration, nitroglycerine, is washed until every trace of acid disappears, for a slight adherence of acid may produce spontaneous combustion. The finished, filtered product is a yellow, oily fluid, called on this account blasting-oil; it solidifies at a not very low degree of cold (12 deg. Cent.). Its vapors are sweet-smelling, but poisonous to breathe and cause violent headache, while the substance explodes with great violence from blow, friction, or sudden rise of temperature. If a drop of nitroglycerine soaks into a piece of filtering paper and the paper is struck on an anvil with a hammer, it detonates with a loud crack. The explosion of nitroglycerine is accompanied by a violent rise of temperature; consequently all powders containing nitroglycerine in the course of time erode badly the arms in which they are used. To overcome this disadvantage inert substances, as vaseline, paraffine, and certain salts are used, but success in this direction always diminishes the force of the explosive.

The combination of these two dangerous substances, guncotton and nitroglycerine, is simply accomplished by kneading the wet nitrocellulose under water with nitro-glycerine. The water in the guncotton is displaced by the nitroglycerine, and the composition thus obtained is made homogeneous by prolonged kneading until the entire fibrous structure disappears. If the content of nitroglycerine is to be reduced by a certain percentage, the kneading is continued with the addition of pure moist guncotton. The soft, plastic mixture, with a horny cutting quality, is formed into various shapes by suitable machinery, and is further worked as are other kinds of powder. Among the number of powders made from nitroglycerine are cordite, balistite, and filite.

A comparison of modern powders with the old gunpowder shows plainly the great advance in the chemistry of explosives which has completely changed the manufacture of arms and the tactics of warfare. Smokeless powder opened the way for rapid firing, and this led to the construction of machine-guns and rapid-firing cannon. Modern powders have three times the force of black gunpowder. A comparison at the moment of explosion of equal quantities of the old and new powders shows that the heat generated by modern powders equals 1,000 to 1,200 calories, by ordinary gunpowder 750 calories, the volume of gas generated in modern powders 900 to 1,000 to 1, in the ordinary powder 300 to 1.

The volume of gas generated by smokeless powders is three times that of ordinary gunpowder, the latter being only partially converted into gas; while modern powders are transformed wholly into gas, leaving no residue. In addition to an improved trajectory modern powders have increased the penetrative power and the range.

The basic substance of smokeless powders is solid and horny. It can, therefore, be formed into any desired permanent, external form, and the rate of combustion can be better regulated for the various ends desired than was possible with the old crumbling gunpowder. Another advance is in the permanence of form of the individual particles as they can be violently shaken together without crumbling or the edges chipping. Consequently, smokeless powder does not suffer from transportation in wartime, while the old powder had to be very carefully handled to avoid a crumbling that might cause unequal ballistic results. In addition, smokeless powder does not absorb water as readily as did the old gunpowder.

(To be concluded.)

Kaolin in the Treatment of Bacteria Carriers*

ALUMINIUM silicate, kaolinum, fuller's earth and bolus alba are various names under which the essentially same substance is familiar to physicians. In 1906, Stumpf of Wurzburg published a detailed report of his experience with it in cholera under the title "A Reliable Method of Treating Asiatic Cholera and Severe Infectious Cholera Morbus, and the Importance of Bolus Alba (Kaolin) in the Treatment of Certain Bacterial Infections." His attention was early attracted to the possible disinfecting virtues of clay by his observation that cadavers exhumed after being buried in clay soil were always in a remarkable state of preservation in comparison with those in other soil. At that time his experience with kaolin covered eight years. He believed that it owed its efficiency in bacterial infections to its action in depriving the bacteria of a suitable culture medium while mechanically burying them alive, separating them from the mucosa and other tissues by a protecting, comparatively impermeable coating. He applied it as a remedy to extensive septic wounds, putrid leg ulcers and the like. Stumpf experimented on himself to determine the harmlessness of the finely pulverized kaolin taken internally in large amounts, and found that it was well tolerated. He administered it in cases of cholera, and found that colics and tendency to vomit were at once arrested. The dose given was 125 gm. of the most finely pulverized kaolin poured on top of half a tumbler of water. After the powder sank to the bottom of the glass, it was thoroughly stirred in with a spoon, and the whole amount taken at once or within a few minutes. After an interval of three hours, the same dose was repeated. In the case of infants and children, they were given proportionately smaller doses.

More recently, kaolin has been given as a gastric astringent; it has been much used in the treatment of cholera and dysentery, and its harmlessness has suggested its use as a substitute for bismuth in taking Roentgen-ray pictures of the gastro-intestinal tract when bismuth cannot be tolerated. In the present European war, the physicians in the German and Austrian armies are using large amounts of kaolin to combat dysentery and cholera, and according to Stumpf,[1] the microscopic findings in the feces of the patients treated fully warrant its use. Wolff-Eisner,[2] from his experience in the war, believes that kaolin has been triumphant in the treatment of cholera. He tabulates twenty-five cases, showing almost immediate stopping of diarrhea in dysentery and typhoid after a dose of a double spoonful each of kaolin and charcoal had been taken from one to three times a day. In severer cases, the proportion of kaolin was doubled. He regards the kaolin-charcoal treatment as a kind of immunotherapy, basing his belief on Hofmeister's dictum that all the phenomena of immunity are colloid chemical reactions. He believes that the kaolin binds toxins which are beyond the reach of serotherapy. The method was applied to healthy carriers and was apparently successful, as no bacilli could be found in the stools after the treatment was administered.

Von Willuki,[3] encouraged by the use of kaolin in the treatment of cholera and dysentery by the methods advised by Stumpf, has used it in two cases of paratyphoid bacteria carriers. In both of these cases, following the treatment with bolus alba, the organisms were found to have very quickly disappeared from the stools.

According to Hektoen and Rappaport,[4] by insufflating kaolin powder in the nose, they are able to remove the diphtheria organism as well as streptococci from the nasal mucous membranes. The swallowing of the powder is followed apparently by a rapid disappearance of the diphtheria organism from the throat. These results are significant.

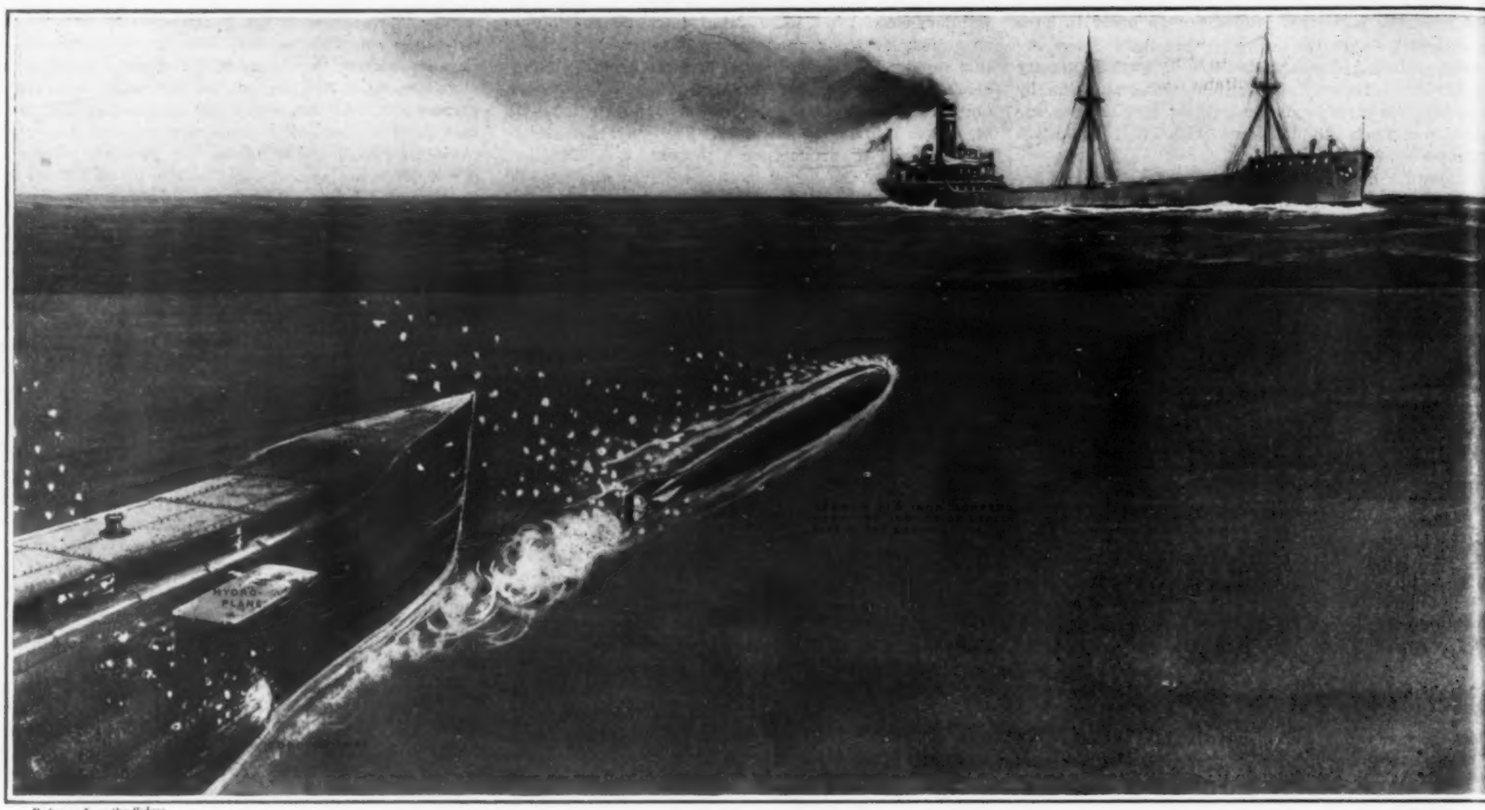
* *Journal* of the Am. Medical Association.

1 Stumpf, J.: Bolus Alba in Diarrhea, Dysentery and Cholera, München. med. Wchnschr., 1914, lxi, No. 40.

2 Wolff-Eisner: Kaolin Charcoal Treatment of Diarrhetic Processes, Therap. d. Gegenw., 1915, xvii, 92.

3 Von Willuki: Bolus Alba in Paratyphoid, München. med. Wchnschr., 1914, lxi, 2356.

4 Hektoen, L., and Rappaport, B.: The Use of Kaolin to Remove Bacteria from the Nose and Throat, *The Journal* A. M. A., this issue, p. 1985.



Redrawn from the *Sphere*

German submarine discharging a 21.5-inch torpedo at an unarmed merchantman. The torpedo is shot from one of the bow tubes by compressed air and travels under its own power at a speed of 30 to 40 knots.

The Automobile Torpedo*

Its Problems and Their Solution

THE menace of the torpedo is a fact in modern warfare of which England had been forewarned by Sir Percy Scott. It and the submarine when in their infancy were objects of sentimental dislike to men whose service traditions were nourished on above-board attacks. Until recently, too, the custom was to underrate the efficiency of these weapons. It is not wise now to rush to the other extreme, since the deadly character of the torpedo is subject to certain limitations, chief among which is the fact that unless it actually hits its mark it is thrown away.

The problems to be solved include those which are concerned with the due control of the movements of the torpedo after it has left its tube, in addition to its initial direction of discharge. The wonderful beauty of the intricate mechanism by which the missile is rendered as nearly as possible instinct with human intelligence renders it an object of perpetual admiration even to matter-of-fact engineers who have grown accustomed to the study of automatic mechanisms. The torpedo should go as straight to its mark as though a human pilot were directing its movements. Within the cigar-shaped shell of steel, from 18 feet to 21 feet in length and 18 inches to 21 inches diameter at the largest part, mechanism is inclosed worth from $3,500 to nearly $5,000, all as delicate as watchwork. It includes a swiftly rotating engine, shafts, and gears, a gyroscopic apparatus, and from 200 pounds to 250 pounds of high explosive. Very properly the details of the designs are concealed from the public as rigidly as are any trade secrets, but the essential elements are common property.

The torpedo entering the water at a slight angle must pass to a certain predetermined depth, from which it must not vary by any sensible amount. Neither may it be permitted to become diverted from the exact lateral course imposed upon it at discharge. In each direction, vertical and horizontal, it must, to be effective, be compelled to pursue a perfectly straight path. It must also carry enough compressed air, its motive energy, to supply the engines throughout the range of its attack. Nor, as the supply becomes drawn on and lessened, may the speed of the engines be sensibly reduced. The rotation of the propellers must not be permitted to cause rolling of the cylindrical-shaped body. Precautions must be taken to prevent the accidental detonation of the highly explosive charge, both when the missile is sent on its course, and during its travel, until it is arrested by contact with its objective. Then provision has to be made to avoid a glancing blow. In some cases also there is an arrangement by which a torpedo which has missed its mark is caused to sink and remain harmless at the bottom. These are the cardinal problems to be solved, but there are many subsidiary ones.

* The London *Times Engineering Supplement*.

WHITEHEAD DESIGN.

In torpedoes, the Whitehead design is of principal interest because it is the chief survivor of numerous rivals, and it is the one which is used more than any other. It was invented in 1868 by an English mechanical engineer of that name, then at the head of an engine factory at Fiume. Mr. Robert Whitehead had been approached in 1864 by a Capt. Lupuis of the Austrian navy, with suggestions for the propulsion of a torpedo along the surface of the water, its propulsion to be effected either by steam or by clockwork, and its movements to be controlled by means of ropes and guiding lines from a fixed base. Mr. Whitehead, abandoning that too crude suggestion, worked at the problem of designing an automobile torpedo which would run under water, and after a couple of years' experimenting he evolved the first of the type which bears his name. This was 14 inches in diameter, and was operated by compressed air at 700 pounds per square inch, but its speed was only six knots, and that for very short distances. It was built of steel boiler-plate, and its explosive charge was 18 pounds of dynamite. But it lacked the balance chamber, without which its vertical movements could not be controlled at a uniform depth, so that sometimes it would remain on the surface, while at others it would dive to the bottom and there explode. Other trial torpedoes were made for the British Admiralty, the result of which was that the government purchased the secret and the right of manufacture for £15,000. A period of active experimenting followed. One important result was the firing of torpedoes from above water, the early ones being discharged from below. Another was the invention and application of the servo-motor to the steering apparatus, by which the steering of the human helmsman was imitated and emulated. In 1897 the gyroscope with its steering engine was applied, and later the heating apparatus. From time to time advances have been made in speed, in range, in the design of the propellers, in safer methods of firing the charge, in increased working pressure, and so on.

SPAR TORPEDO.

Increase in speed has been rendered necessary by the growth of quick-firing guns of long range and increase in the explosive charge by the improvements in armor and the more numerous subdivisions of the water-tight compartments of ships. In this respect contrast may be made between the old spar torpedo, which dates back to the American Civil War, and the torpedo as we now know it. The spar torpedo achieved some measure of success, because the day of long-range guns had not then arrived; it could do damage only when the attacking vessel was within a few feet of its objective, and attacks could not be delivered with safety except under cover of night. It was a delicate piece of mechanism nevertheless, and readily caused damage to those who handled it carelessly.

The name was derived from the wooden spar, to the outer end of which the torpedo was fitted. The latter comprised two canisters filled with guncotton, which were fitted over the iron-shod end of the spar, a beam of timber about 42 feet in length, and tapering from 6 inches to 5 inches in diameter. Wires leading from the battery on board the ship fired a detonator in a primer tin behind the tins of guncotton. The spar was run out and depressed under water to a depth of at least 10 feet, and the torpedo was then fired close to the vessel attacked. This and other types antedated the Whitehead. During the American Civil War the Confederates destroyed several Federal ironclads, 13 wooden war-vessels, and seven transports, and damaged eight other ships with torpedoes, which were either anchored like mines in channels or were exploded alongside vessels from a boat.

CONSTRUCTION OF THE BODY.

The name torpedo is only a generic term, since large numbers of patterns are made. The description that follows must therefore be of a character generally applicable to the Whitehead type.

The outline of the torpedo is fish-like (Fig. 1), the nose, or war-head, is blunt, and the body tapers away to the tail. In the earlier forms the nose was sharp, to form a cutwater, but it was soon learned that a spherical coned, bluff type of head offers less resistance to the water than does the finer head. The reason is that the conditions of under-water resistance are different from those of surface wave resistance; hence the superiority of the fish-like outline.

The casing is thin, of steel, polished. It is built in distinct sections, which correspond with the situations of the principal portions of the mechanism. These comprise, in order from the nose, the chamber that contains the explosive; the large chamber which receives the store of compressed air for working the engines; the balance chamber, in which the horizontal steering apparatus is contained; the engine-room; and the buoyancy chamber, in which the lateral steering apparatus is carried; while outside at the tail are the

Launching a torpedo.

rudders, the propellers, and the fins, which help to keep the torpedo straight in the water.

THE NOSE.

The term war-head denotes the active head, that is, the nose charged for its destructive work, to distinguish it from a dummy head which is used for practice. The latter is of steel, ballasted with teak wood to weigh about as much as the war-head. The war-head is

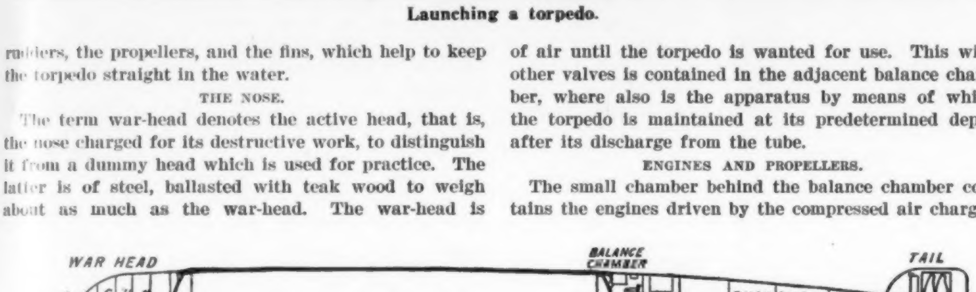


Fig. 1.—Diagram of Whitehead torpedo.

charged with guncotton, which is exploded when a striker (*A*, Fig. 1) that projects from a tube—the pistol—which passes through the center of the body of guncotton strikes the side of a ship. This striker detonates a small charge of fulminate of mercury, which explodes a primer charge of dry guncotton inclosed in a tube in the rear, and this in turn detonates the charge of moistened guncotton, weighing 200 pounds, or more, that occupies the greater part of the space in the war-head. The charge is inserted in the form of segmental layers.

But provision has to be made to prevent the accidental premature contact of the striker or pin which detonates the charge before the torpedo has been sent from 40 to 100 yards on its course. A fan *B* is therefore screwed to rotate freely on the striker just behind the point. Its function is that of a check-nut, to prevent the striker *A* from being knocked backward prematurely. When the torpedo is discharged, the fan by its rotation runs clear off its screw, after which the striker is left the necessary freedom of movement to act on the detonator. Then a pin must be shorn off by the forcible driving in of the detonator before the latter can detonate the fulminate. This arrangement is adopted in order to avoid an explosion, following only a slight concussion, such as might be caused by contact with a floating object.

Behind the fan are the whiskers *C*, the object of which is to insure due end-on contact with a ship, when the torpedo happens to strike a glancing blow. The whiskers extending in front swing the torpedo round.

AIR CHAMBER.

Immediately behind the war-head is the air chamber, occupying about one half the length of the tube. On the cubic contents of this chamber, and the high pressure, with the air-heater to be mentioned presently, depend the high speed and long range of the later torpedoes. The chamber is charged with air from pumps when required for action, or usually once a day, through a charging valve. The pressure is very high, 2,000 pounds or more to the square inch, with a test pressure of 3,000 pounds. The ends of the chamber are concave, the better to resist the stress, and the material used is the finest compressed steel, about ⅝ inch thick. In consequence of these high pressures the weight of the air, from 30 pounds to 60 pounds in different sizes, is so great as to reduce the natural buoyancy of the chamber. A stop-valve also is necessary to prevent leakage of air until the torpedo is wanted for use. This with other valves is contained in the adjacent balance chamber, where also is the apparatus by means of which the torpedo is maintained at its predetermined depth after its discharge from the tube.

ENGINES AND PROPELLERS.

The small chamber behind the balance chamber contains the engines driven by the compressed air charged into the large air chamber. These are of the Brotherhood three-cylinder or four-cylinder type. They are single-acting, the air exhausting through ports in the ends of the cylinders and thence being discharged through a tube at the tail. A pipe conducts the air from the air chamber through the stop-valve which is opened before the torpedo is placed in its tube. The charging valve, situated in the balance chamber, is a non-return valve used only during the charging of the torpedo. Air passes through the stop-valve to the starting valve, which is opened automatically by cam action when the torpedo is launched, and closed similarly when the motion of the torpedo is arrested. Further, to prevent the racing of the engines and propellers during the short period when the torpedo is passing through the air into the water, a delay valve is fitted to reduce the supply of air during that interval. Yet one more valve is required to regulate and equalize the pressure of air to the engines; without this the pressure would fall continuously as the compression became reduced in the chamber. The air therefore is compelled to pass through an annular reducing valve and ring with ports, the relations of which are controlled by a spring set for a definite pressure. Variations in pressure are compensated for and eliminated by the control which the spring exercises on the relative position of the ports.

The tail end of the torpedo, which is a continuation of the buoyancy chamber, contains miter-gears for turning the four-bladed propellers in opposite directions, to prevent the torpedo from rolling; one set is on the engine shaft itself (Fig. 2) and the other on a sleeve encircling the tail-end of the shaft and driven by the gears. Outside the tail are the vertical rudders which are operated by the gyroscope, and the horizontal rudders worked by the balance mechanism to be noticed directly. Generally also there are vertical fins above and below, and often others at the sides, to assist in steadying the torpedo.

AIR-HEATER.

The most important later addition is an automatic heater which warms the air. It is started by the discharge of the missile. In one design a firing pin is caused to strike a cartridge, which deflagrates and burns in a vessel into which an oil fuel is injected. The compressed air passing through this vessel becomes heated and expands. At the same time the injection of fresh water from a tank lowers the temperature of the

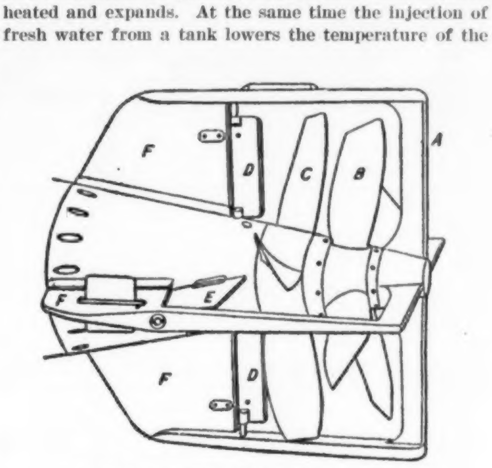
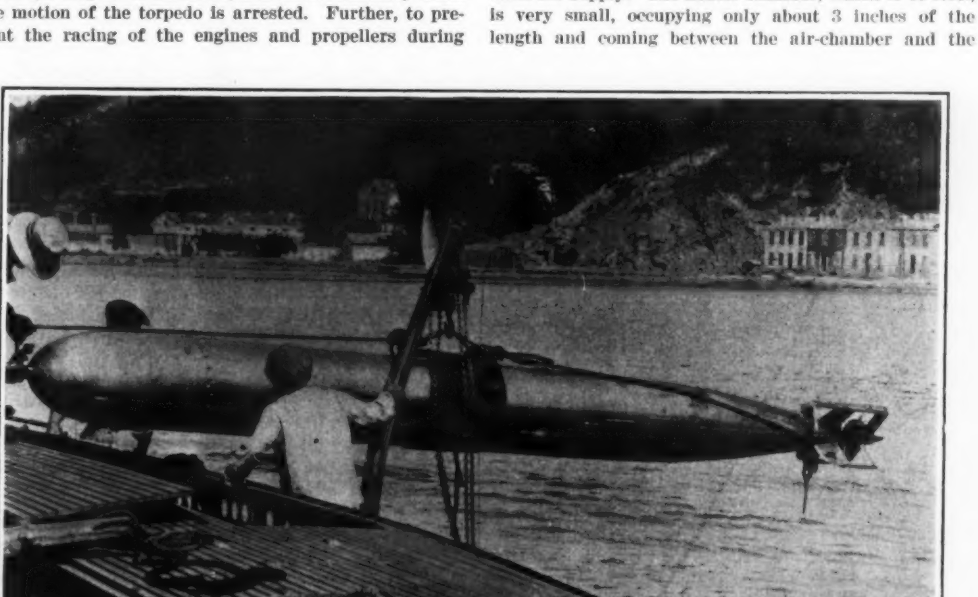


Fig. 2.—Tail of Whitehead torpedo.

A, protective framing; *B*, propeller on engine shaft; *C*, propeller on sleeve, driven by miter gears; *D*, vertical rudders worked by gyroscope; *E*, horizontal rudders worked by balance mechanism; *F*, fins.

engine cylinders. The energy of expansion being increased, the consumption of air is reduced, and the torpedo is able to cover twice the distance with the same air supply. The heater chamber, which is of steel, is very small, occupying only about 3 inches of the length and coming between the air-chamber and the



Hoisting a spent torpedo on board.

engine-room. The gain in power is shown by the following table, the experiments being on an 18-inch torpedo:

	With Cold Air	With Heated Air
	Knots.	Knots.
Speed at 1,000 yards	35	43
" " 1,500 "	30	40
" " 2,000 "	28	38
" " 3,000 "	23	32
" " 4,000 "	18	28

DEPTH MECHANISM.

The automatic apparatus for maintaining the torpedo at the proper depth, though subject to variations in detail, comprises substantially a hydrostatic valve, a heavy swinging weight, and a powerful mechanical aid to the steering gear—the servo-motor.

The torpedo is set to run at a certain depth by means of the hydrostatic valve placed in the upper part of the balance chamber. When that depth is exceeded the pressure of the water forces the valve inward. The precise depth is set by compressing a spring on the valve, the depth to which it corresponds being read on an indicator marked in feet. When the torpedo descends below the depth for which the spring has been set, the pressure of the water forces the valve inward, overcoming the resistance of the spring, and the movement of the valve is transmitted by a rod to a series of levers which are connected to the swinging pendulum in one direction and to the horizontal rudders in the other. The pendulum weight swings fore and aft under the movements of the valve, and controls the movements of the rudders, which are swung upward or downward in response to the delicately adjusted controlling influence of the valve, pendulum, and levers. Further, to prevent the rapid discharge of the torpedo from throwing the pendulum violently backward and holding it in that position, so causing the torpedo to dive, an extra controlling gear is fitted. Its action is such as to keep the rudders fixed during the initial stages of travel until the torpedo has got well under way. The servo-motor comprises a cylinder, piston, and slide-valve actuated by the compressed air used for the engines. The slide-valve is operated by the balance mechanism. By its means the movements of the mechanism of the balance chamber are assisted by the power of the motor, the movements of the piston being transmitted to the

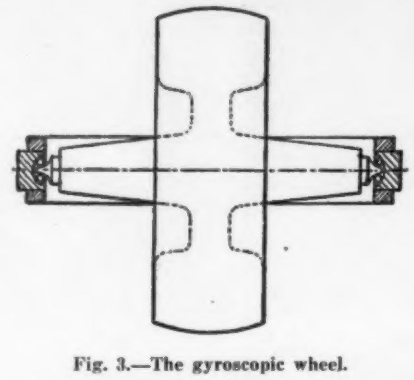


Fig. 3.—The gyroscopic wheel.

mechanism to assist those of the rudder. It constitutes, in fact, a miniature power steering gear.

GYROSCOPIC STEERING APPARATUS.

Behind the engine-room, in the buoyancy chamber, is the beautiful gyroscope, making over 2,000 revolutions per minute. This controls, through the pair of vertical rudders, the lateral course of the torpedo, and also acts through a servo-motor or steering engine. The gyroscope wheel is suspended on gimbals (Fig. 3), like a ship's compass, in a vertical position, and transversely in relation to the axis of the torpedo. It is set by the winding-up of a powerful spring. The discharge of the torpedo releases the spring and allows the gyroscope, which weighs less than $2\frac{1}{2}$ pounds, to revolve. As the momentum of the wheel tends to maintain it in the same plane of revolution, any deviation of the torpedo from that plane is resisted by the momentum of the wheel. Acting on the rudders through the servo-motor it automatically brings the tube back to its proper course. It is possible thus to maintain the torpedo in an absolutely straight course up to a distance of 2,000 yards. Yet an error of only one degree would become a lateral error of 50 feet at 800 yards.

THE AMERICAN TORPEDO.

The largest torpedoes, the Bliss-Leavitt, used in the United States Navy measure 21 feet long by 21 inches in diameter. Some are designed for a range of 10,000 yards and some for 4,000 to 5,000 yards, the latter at a high speed, or about 35 knots. They differ in several details from the Whitehead and are more costly, roughly $5,800, against $3,300 for two torpedoes of nearly equal power and range. They are manufactured in two sizes, 18 inches and 21 inches in diameter. The sections into which they are divided comprise the head, the air chamber, the afterbody, and the tail. The air chamber includes a central portion flanked by a buoyancy chamber at each end. That at the front is the buoyancy chamber proper; that at the rear contains the diving gear and the alcohol bottle by which the air is heated on its way to the engines. The alcohol is ignited by an automatic pistol to a temperature of about 900 deg. Fahr. The air is compressed in its chamber to 2,350 pounds per square inch, reduced to 450 pounds in its passage thence to the engines.

The engines are of the Curtis turbine type. Their advantage over the three or four-cylinder design is that of greater compactness, so allowing increased storage room and utilizing better the superheated air. Two turbine wheels rotate the propellers in opposite directions in order, as mentioned previously, to counteract the tendency of the torpedo to roll. An engine weighing only 45 pounds develops 125 horse-power. The gyroscope is also started by a small air-driven turbine instead of by a spring, and clockwork automatically draws this turbine out of engagement with the wheel, leaving the latter to continue spinning, which it will do for 40 minutes. Operating on the vertical rudders, it acts like a helm in correcting incipient minute deviations to right and left. The two propellers are each four-bladed. There are four rudders, two horizontal for depth and two vertical for lateral steering. The head contains 200 pounds of guncotton, an amount which, if it could be fully utilized, would give energy sufficient to raise a ton six miles.

The casing of the torpedo is made of different materials and thicknesses. The most important portion is the air chamber, which is tested to a pressure of 3,000 pounds per square inch. It is made from a solid ingot of nickel steel worked into a shell form with walls about $1\frac{1}{2}$ inches thick. This is then turned and bored down to a thickness of $\frac{1}{16}$ inch, followed by heat treatment. The heads are fitted into it. The war-head is of sheet steel $\frac{1}{16}$ inch thick, made in halves and brazed; the afterbody is made similarly. A device, termed a sinking gear, is provided with the object of sinking the torpedo in case it does not hit its target. If this were not done the floating torpedo might constitute a menace to the ships of the fleet to which it belongs.

The Jitney Problem—II*

Its Regulation, Its Relation to Street Railways, and How They Can Meet the Movement

By J. C. Thirlwall, Railway Engineering Dept., Gen. Elec. Co.

Concluded from Scientific American Supplement No. 2069, Page 144, August 28, 1915

Data have been collected and a comparison is made between the assumed costs and revenues on two lines, one in Texas, and one in Alabama.[1] In both cities, the performance of the standard type of equipment is contrasted with that of the suggested light weight cars. In the first, a small number of cars purchased in the past three years are somewhat lighter in weight than the ones used in the present calculations, but the latter represents the greater part of the existing equipment. In both places, the cars are of the size and weight shown.

On the Texas road, power costs are fairly normal and rush hour congestion is not so excessive as to require the use of trains, nor of trailers during rush hours. Medium sized cars of fairly light weight have handled traffic satisfactorily. The greatest handicap here has been a very high number of stops per mile, combined with slippery rail conditions during a great part of the year, which has resulted in extremely slow schedules on many lines. The frequency of stops in spite of slow speed has meant unusually high power costs. The other city has large factory crowds to handle, and has extreme congestion of traffic during the rush hours, necessitating large capacity two-car trains at present. The stops, however, are comparatively infrequent due to long city blocks, schedule speeds are high, and power consumption is relatively low. The cost of power is also unusually low here. These causes combine to make the platform wage item much larger in proportion to the power cost than it is in most cities.

In both cities, the railroads have been hard hit by the the jitney competition. In both, the substitution of lighter cars and operation of shorter headways would seem to offer a solution of the difficulty.

For the Alabama road all data are based on two-men per car. Platform wages are taken at 50 cents per hour for single cars and at 75 cents per hour for two-car trains.

Maintenance and depreciation of equipment and way are taken at 3.5 cents per car mile with heavy equipment, at 3 cents per mile with the medium weight cars, and at 2.4 cents per mile for the small cars.

Power costs are figured at 0.55 cents per kw-hr. per car mile for the large cars and 3.5 kw-hr. per car mile during trailer operation. The type *B* cars are figured at 2.5 kw-hr. per car mile and the small cars at 1.1 kw-hr. per car mile. Variations from these figures, due to total causes, such as low voltage, improper handling of the equipment, etc., would not change the relative values.

Miscellaneous traffic expense and general expenses are totaled at 4.9 cents per car mile on the present mileage. The actual costs of these two items are assumed to be unchanged by the change in car type or by increased mileage.

Transportation revenues are estimated at 23 cents per car mile.

All figures except platform wages and power consumption are based on the average cost of operation for this property in 1914, and the power rate is also taken from their cost sheets. Both wages and power consumption agree closely with the actual averages for all their equipment.

The data for the Texas road are based on the following assumption: Platform wages are taken at 50 cents per hour for single cars in first three columns, and at 30 cents per hour for the one-man cars; for two-car trains, at 75 cents per hour.

Maintenance and depreciation of equipment is figured at 4 cents per car mile at present, and at 2.7 cents per car mile with the light weight cars, and at 3.5 cents per car mile with the class *B* cars.

Power costs are figured at 1 cent per kw-hr. and on a basis of 3 kw-hr. per car mile for the type *A* cars, 2.5 kw-hr. for the type *B* cars, and at 1.1 kw-hr. for the type *C* cars. Variations from these figures for local causes, such as low voltage, improper handling of the equipment, etc., would not change the relative values.

Miscellaneous traffic expenses and general expenses are taken together at 4.75 cents per car mile on the basis of the present mileage, and the actual costs of these two items are assumed to be unchanged by the use of a different car type, or by increases in mileage.

Transportation revenues are estimated at 24 cents per car mile on the present mileage.

All figures, except platform wages and power costs, are based on the average operating statistics for Southern Railways contained in the United States census report of 1912, and both platform and power costs as figured above agree closely with the averages of the census report.

DISCUSSION OF DATA

In the preceding data, slight variations in the actual hourly wage of motormen or conductors would not change the relative values of platform expenses, nor would the result be changed if somewhat different values are assumed for general expense and miscellaneous traffic costs. The two items named are inherently stable, and would not be increased in any way that is apparent to the writer by a change in the type of equipment, nor by a moderate increase in the number of cars in service.

The two items which might reasonably be questioned are the maintenance and power charges. Assuming that maintenance and depreciation are now 4 cents per car mile (which is the average for Southern roads), we find from Mr. Doolittle's article in the March issue of the *Aera* that the items which go to make it up are as follows: an average being taken of the East South Central and West South Central data.

* *General Electric Review.*

[1] Large railway, light and power company in Alabama trip.

A—Present cars—56,000 pounds, seat 48; pull trailers 33,000 pounds, seating 60.

B—Suggested cars—30,000 pounds, seat 52.

C—Suggested cars—12,000 pounds, seat 32.

	Cents.
A—Way structures, superintendence	0.095
B—Maintenance of way	1.315
C—Maintenance of way, electric lines	0.330
D—Buildings and structure	0.08
E—Depreciation of way and structures	0.15
F—Other operations	0.11
G—Equipment superintendence	0.085
H—Maintenance of power equipment	0.21
I—Maintenance of cars and locomotives	0.84
J—Maintenance of electrical equipment of cars	0.42
K—Miscellaneous equipment expense	0.115
L—Depreciation of equipment	0.19
M—Other operations	0.115
Total	4.055

Of the above, items A, D, F, G, K and M would probably not be affected, insofar as total expenditures are concerned, but if the mileage made is increased, the cost per car mile for these items would be proportionally decreased. The average weight on the road with the small cars would be about one third of what it is at present, and the actual effect on damage to special work, and to the substructure and paving should be reduced proportionally. Rail wear too would be about proportional to the weights; but on the other hand wear and tear due to the other traffic and to the elements would not be changed. It seems reasonable therefore to place the figure for light cars at one half of the present value, or 0.66 cents.

The maintenance of electric lines would also drop as a result of reduced currents at the trolley wheel. This reduction is estimated at 20 per cent, giving a revised figure of 0.264 cents.

Depreciation of way and structures might decrease one third, and becomes 0.10 cents.

Maintenance of power equipment, due to the greatly decreased load should decrease at least one third and becomes 0.14 cents.

Car maintenance, due to reduced brakeshoe and wheel wear, and the more modern design of the parts, should be at least 20 per cent less per car mile, or 0.67 cents.

Electric equipment maintenance, due to the more modern design of the equipment should average not over 0.05 cents. This is based on actual records, on many roads, of motors and controllers put out during the past four or five years.

Depreciation of equipment should be somewhat less, use to improved design and better materials, say 0.15 cents.

In this connection, should the present cars be replaced outright by new cars, depreciation charges would, of course, increase, as the value of the new equipment would have to be added to that of the outstanding value of the old, and a rate set which would wipe out both values within a reasonable period. But if the old cars were retained in service, and used as spares and for rush hour and holiday traffic, they would still be carried in the capital account. This, of course, would be the logical method, and under these circumstances the greater earning capacity of the new cars in proportion to the capital investment should mean a lower proportion of the gross receipts would have to be set aside for depreciation.

The new total, on these assumptions, becomes 2.63 cents, 60 per cent of the present cost. To be conservative, however, the figure of 2.7 cents has been assumed, a decrease of one third.

For the type *B* cars, a figure of 3.5 cents was arrived at by a similar method of estimating.

The biggest item of economy is, of course, in power. Consumptions per car mile are calculated values, and probably agree fairly closely with what is actually taken at present, and decrease in total power consumption would unquestionably be at the ratios shown. But many operators will not agree that the cost per kilowatt-hour should remain the same under the reduced output as under the heavy load. In the case of a company which sells lighting and commercial power there should be no question of this. The reduced railway load simply releases so many kilowatts which can be sold at a profit elsewhere.

In the case of the railway companies that purchase their power, any reduction in their peak load should mean a decrease in rate as well as paying for less kilowatt-hours, and the combined value of these economies should offset the increased cost per kilowatt-hour of their overhead charges for distribution.

It is the operator, however, who neither buys nor sells power who, often, can see no benefit to himself in power reduction, save in a slightly reduced fuel bill. If the reduction is only a very small percentage of the total output, this is ostensibly correct, provided neither his machines nor lines are overloaded. There would be no immediate reduction in either his overhead or labor costs, and the reduction in fuel and maintenance cost might be negligible. But where the reduction in load amounts to as great a proportion of the total cost as in this instance, or approximately two thirds, it should be possible to shut down some units, reduce the number of firemen, and make a general reduction in all the costs of operation of the power plant. There would be a distinct reduction in the line losses, which in many instances would act to postpone the installation of additional copper in the distributing system. If these indirect economies did not manifest themselves immediately, they could unquestionably be secured in the long run, by enabling additional service to be supplied without increase in station or line capacity.

The actual cost of power at the station is, of course, an important factor in this analysis. On the Alabama property it is unusually low. In fact, only a few of the largest railway systems in this country can purchase or produce power for approximately one half cent per kilowatt-hour; and this, of course, does not include interest on their plant or on their distribution system. These are, of course, part of the real cost, but are carried in the fixed charges and not under the operation. The effect of this low rate, however, combined with schedules which require a comparatively low consumption of power, make the cost of power a relatively small item on this system, and the extreme rush hour conditions make the platform account a greater percentage of the total expense than on most roads.

These two reasons, combined, make a car of large seating capacity of more importance to them than one of low power consumption, and the medium-weight car (type *B*) is unquestionably the most efficient.

On the other hand, under normal rates for power, which have been assumed for Texas, and with schedules which require an unusually high consumption per ton-mile, power charges assume a greater importance. Since there is moreover, here, a more even distribution of traffic throughout the day and less pronounced rush hour peaks, platform wages, while still the largest item, are not so great a part of the total as in some other places. Under these circumstances, the small car, even with two-man operation, appears the more efficient; and with one-man operation the saving would amount to a large sum.

Of the economies of one-man car operation there can be no question. Of the advisability of attempting to operate cars in this manner in any save the smaller cities, there are grave differences of opinion. It seems logical that their use under any heavy condition of traffic would materially slow down schedules. The use of one-man cars is prohibited by law in many communities. If the education of the public in the prepayment of fares and the use of transfer and change-making machines obviates the need of a conductor, and the car can be operated as satisfactorily without one, it is obvious that laws will have to be changed to permit of such operation. Such permission would probably be far more easily obtained than an increase in fares. Whether one or two men per car be employed, however, is purely an operating matter; the only way on which it enters into the present paper is that the smaller the car the less the difficulty of single-end one-man operation.

Upon the assumption, though, that in the majority of cities no immediate change in this respect is possible, the other apparent advantages of the smaller cars are so evident that, whether as a means of meeting and fighting other forms of transportation, or simply as a method of securing greater economy under normal operation, it seems perfectly logical to assert that their use will prove decidedly advantageous to the great many urban railways, and that many others could secure greater efficiency by the use of lighter equipment than they are using.

Certain assumptions have been made as to the effect on transportation revenues of cutting down headways and providing faster schedules. In the case of cities where maximum traction trucks are largely used, both accelerating and braking rates on poor rails are necessarily low as compared to single-truck or to four-motor equipments, and this usually results in slower average schedule speeds than could otherwise be secured, since the schedules have to be laid out with the most adverse conditions in mind. Bad rail conditions, due to greasy or muddy tracks, are common here during many months of the year, and rates of acceleration and braking are slower than is usual even with maximum traction equipments. The advantage of the single-truck car in respect to rail adhesion, together with the fact that the use of more cars will decrease the average load per car per trip, and therefore there will be fewer stops made per trip, make it certain the running time at all hours of the day could be materially shortened.

This, in itself, would prove popular, as passengers object strongly to slow schedules, and especially to the loafing which motormen so often resort to on the lighter trips of the day when with a good rail and few stops they get ahead of schedule. But the most potent factor in promoting the riding habit, and in securing business which is otherwise lost, is a short headway and the running of cars absolutely on time. It is no exaggeration to say that a man who lives not more than two miles from his business will very frequently walk sooner than wait ten minutes for a car, and that the average person who has a mile to go will walk sooner than wait above five minutes. The greater number of riders per capita in the largest cities as compared with smaller communities is due in part to the longer distances between the business and residential sections, but is also very largely brought about by the greater frequency of service in the former places.

If headways of from six to twelve minutes were cut one third, and a faster schedule at the same time offered, it appears reasonably certain that the number of passengers would increase at least 20 per cent. Intermediate cuts in headway should produce increases in receipts of from 10 to 15 per cent. These figures are, of course, mere guesses, but are the estimates of a considerable number of men, and based largely on their own experience; in other words, is an estimate of the number of rides they take weekly on street cars as compared with the number of times they walk in preference to waiting. Jitneys, of course, catch numbers of such passengers; so do private car owners who see friends walking and pick them up.

In short, to furnish improved service will bring in an increased amount of business, and will at the same time reduce public criticism and hostility, which is the most serious handicap with which most public service corporations have to contend. If it can be done without a prohibitive increase in the costs of operation, it will prove a mutual benefit to the public and operators, and should be the means of placing the electric railways on a firmer financial footing.

Vaccine Virus Not the Cause of Tetanus

Interesting scientific studies dealing with the relation of tetanus to vaccination were recently completed by Director John F. Anderson of the Hygienic Laboratory, U. S. Public Health Service.

Dr. Anderson states that tetanus is never contracted through vaccine virus, and he presents evidence which goes to prove that the limited number of authentic cases developing after inoculation have invariably been due to contamination of the wound subsequent to vaccination.

During the last thirteen years the Hygienic Laboratory, charged by law with the regulation of the manufacture and sale of vaccines and serums, has examined specifically for the organism of tetanus sufficient vaccine to vaccinate over 2,000,000 persons, and in not a single instance was the presence of tetanus bacilli established. Monkeys, which are susceptible both to vaccination and tetanus, were inoculated with virus heavily contaminated with tetanus spores. While developing "takes" they remained absolutely free from symptoms of tetanus. The same treatment was accorded guinea pigs, equally susceptible to the disease, with similar results. Moreover, the laboratory in several instances fortunately secured the remaining samples of vaccine supposed to have caused tetanus, but examination by the most delicate tests failed to show contamination, conclusively proving that the infection was not contained therein. Records of the Army and Navy were investigated over a period of eleven years. Not a single case of tetanus, of the eight occurring during that time, was traceable to the 585,000 vaccinations performed.

Since 1904, Anderson has kept accurate records of all cases of tetanus which were supposed to be connected in any way with vaccination, and has obtained data covering forty-one such instances, twenty-nine of which ended fatally. This is a much smaller number than is commonly supposed. Additional cases were reported, but upon investigation they were found not to be tetanus, or to be clearly attributable to infection through wounds. These records comprise such data as the number of persons vaccinated, result and character of the operation, the firm manufacturing the virus, and other essential facts. In the majority of the forty-one cases studied it was learned that many others were treated with the same lot of virus without harmful effects. This in itself suggests that the vaccine was not the causative factor. Tests of the virus from the original packages failed to reveal the presence of the tetanus organisms, and thus substantiates this conclusion. During the period mentioned, it is estimated from manufacturers' reports that over 31,000,000 people were vaccinated. The investigator concludes that if the virus was responsible infection would have been much more widespread. Dr. Anderson further shows that under average conditions tetanus develops within ten days from the receipt of an injury or the time of inoculation. The fact that in the few recorded instances following vaccination it did not develop until nearly twenty-one days after the treatment indicates that inoculation took place subsequent to the vaccination.

The investigator concludes that where tetanus manifests itself infection is received by the contamination of the vaccination wound in the same manner as the infection of any other surgical wound, and that with the ordinary precautionary measures there is not the slightest fear of the development of the disease.

Pyrometers for Shop Use*

Principles Governing the Design and Construction of Electrical Pyrometers

By J. M. Johnson

Within the last few years, the importance of the pyrometer has greatly increased owing to its extensive application in the heat-treatment of steel, and also to the general recognition of the fact that a more uniform product can be turned out by less highly skilled men using accurate instruments than by men of the widest experience in the heat-treatment of steel who determine temperatures by the "color" method. Furthermore, pyrometers are the means of saving expense due to loss of work through over-heating, and the consumption of an unnecessary amount of fuel to obtain a desired result. In several commonly used types of pyrometers, the accuracy of the results obtained with the instruments is dependent upon the way in which they are used. But as many foremen and others engaged in the heat-treatment of steel often know relatively little of the underlying principles upon which the instruments that they use operate, such men fail to obtain the degree of accuracy of which the pyrometers are capable. As a result, the instruments are blamed where the real cause of complaint is attributable to the ignorance of the workman. Realizing the importance of this condition, it is felt that the following article describing the fundamental principles of the design and use of pyrometers will be of value to many readers.

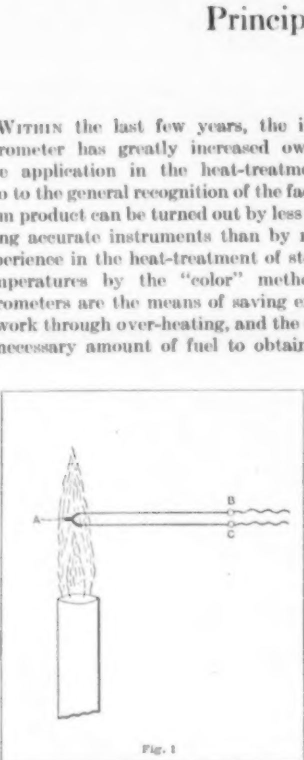


Fig. 1.—Diagram illustrating principle of thermo-electric couple.

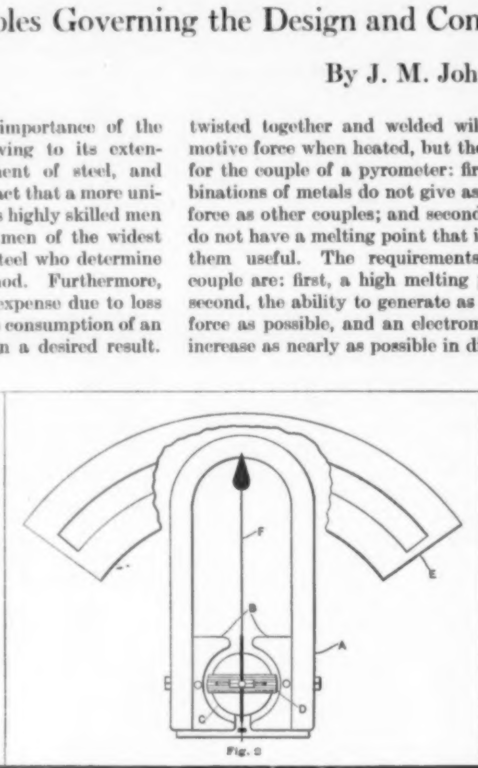


Fig. 2.—Principal parts of a typical form of millivolt meter, which measures the small voltage of the thermo-couple.

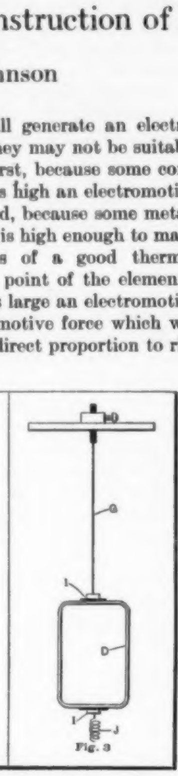


Fig. 3.—Coil of suspension type of pyrometer.

A BRIEF HISTORY OF PYROMETERS.

By pyrometer we mean an instrument used to measure temperatures over 500 deg. Fahr. Perhaps the first instruments made use of as pyrometers (if they may be called such) were the Seiger cones which were made from clay and placed in a furnace whose temperature was to be ascertained. These cones would soften and bend over when the temperature for which they were calibrated was attained. They, of course, were of little use, as they did not show whether the temperature was rising or falling, and when once used were rendered useless. Another early form of pyrometer, now used to some extent (the copper bomb) consists of a vessel of water with a low range thermometer in it. A copper ball of known weight is placed in the furnace whose temperature is to be measured, and after leaving the copper ball in the furnace long enough to acquire the same temperature as the furnace, it is quickly transferred into the vessel of water. The increase in the temperature of the water is noted, and by reference to the table supplied by the maker of the pyrometer, the temperature of the furnace is obtained. Other types of heat gages could be mentioned, but very few of them are practical enough for the measurement of high temperatures to be worthy of mention. The only really practical instrument yet devised is the one to be described, which operates on the thermo-electric principle.

DIFFERENT THERMO-COUPLES AND THE FUNDAMENTAL PRINCIPLES OF THE THERMO-COUPLE.

When two dissimilar metals are held in contact and the point of contact is heated, a small current of electricity is generated, and in most cases the magnitude of this current is proportionate to the intensity of the temperature. As an example, when an iron and a copper wire are twisted together and welded and the junction *A*, Fig. 1, is heated, a current of electricity is generated due to the difference of temperature between the hot junction *A* and the cold junctions *B* and *C*. The greater this difference in temperature between *A*, *B* and *C*, the greater the voltage generated. Any two unlike metals when twisted together and welded will generate an electromotive force when heated, but they may not be suitable for the couple of a pyrometer: first, because some combinations of metals do not give as high an electromotive force as other couples; and second, because some metals do not have a melting point that is high enough to make them useful. The requirements of a good thermocouple are: first, a high melting point of the elements; second, the ability to generate as large an electromotive force as possible, and an electromotive force which will increase as nearly as possible in direct proportion to rise in temperature in order to obtain a uniform scale; and third, constancy of couples throughout their life.

To meet all these requirements we find that our choice of metals is cut down to a comparatively small number. Platinum and platinum rhodium is a thermo-couple largely used. One wire is pure platinum and the other platinum alloyed with 10 per cent of rhodium. This couple is what is known as the Le Chatelier couple, and is considered a standard when received with a certificate giving the millivolts corresponding to degrees of temperature. This certificate is issued by the maker and can, for a small fee, be certified by the Bureau of Standards at Washington, D. C. The objection to this couple for everyday shop use is its high cost and the small electromotive force generated, which amounts to only 17 millivolts (0.017 volt) when the junction *A*, Fig. 1, is heated to 3,000 deg. Fahr. and the ends *B* and *C* are at 32 deg. Fahr. This couple, in common with other couples, absorbs gases rapidly and becomes very brittle, causing it to break easily after some months of use, if it is not properly protected. The electrical resistance of the couple is also very high, and being nearly a pure metal couple its temperature coefficient is very high, which is an objection in shop use, as will be explained later; although in the laboratory it is undoubtedly the recognized standard where the proper conditions can be had for its use.

THE INSTRUMENT OR MILLIVOLT METER.

This is the name given to the instrument which measures the small voltage generated by the thermo-couple, and which is calibrated to read in degrees Fahr. or Cent., as the case may be. As before stated, the voltage generated by the thermo-couples, even with the strong base metal couples, is only a few thousandths volt, so that a very sensitive instrument is required to record it. There are two distinct types of millivolt meter movements in use, i. e., the "suspension type" and the "pivoted type," and as regards their electrical construction they are quite similar, differing only in their method of supporting the moving elements carrying the pointer. Both types have five distinct parts, namely, the magnet, moving coil, pointer, scale and control springs (or suspension). The magnet is generally of U-shaped design, as shown at *A* in Fig. 2, and has two pole pieces *B* fastened to its ends. The pole pieces are accurately bored out, and a round core *C* is supported in this space. The core is somewhat smaller than the opening of the pole pieces, thereby leaving an annular opening in which the coil *D* moves. The purpose of the core *C* is to shorten the path for the magnetic lines of force, rendering the instrument more sensitive and aiding in keeping the strength of the magnet constant.

Fig. 3 shows the moving coil and suspension *G*. The coil generally consists of an aluminium frame, wound with copper wire, the frame serving the double purpose of supporting the wire and suspension sockets *I*, and also renders the instrument "dead beat," due to the Foucault currents generated in it. The suspension type of movement is the only movement that is practical for use with a platinum couple, because it is possible to make this type of movement very sensitive to small voltages, which is necessary with this couple. The disadvantage of the suspension type of instrument for shop use is that it must rest on a very solid foundation and it is not a portable instrument in the true sense. It must be accurately leveled up before using, and it is quite fragile, due to the thinness of the suspension. It also has a rather long damping period, i. e., when using it with a number of couples by means of switches, it takes an appreciable time for the pointer to become steady to indicate the correct temperature. As a laboratory instrument, however, and for very accurate checking purposes, when properly handled, it is a very satisfactory instrument. Fig. 4 shows the most common method of securing the suspension *G* and lower lead spring *J*; this spring exerts no torque on the moving coil, but merely serves to lead in the current. The top suspension, in which the coil hangs, acts as control and lead-in for the current.

The pivoted instrument, as the name implies, has the coil supported in jewel bearings instead of on the suspension. The current is led into the moving coil by means of two flat spirally wound phosphor-bronze springs shown at *A* in Fig. 5, which serve as the control and also for leading the current into the moving coil of the instrument. The pivots *B* are of hardened steel and rest on sapphire jewels. This type of movement is generally the one adopted for shop pyrometers on account of its ruggedness and quickness in coming to rest. After connecting to any one of the several couples it can be located in any position and needs no leveling. The pivoted type instrument is, however, only practical in connection with the base metal couples (base metal couple meaning couples that are not platinum) on account of the greater voltage generated by the base metal couples

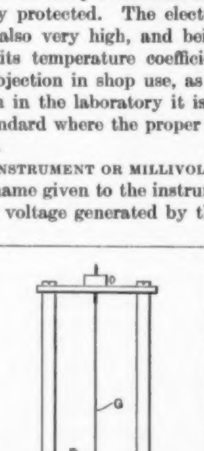


Fig. 4.—Method of securing suspension G and spring J.

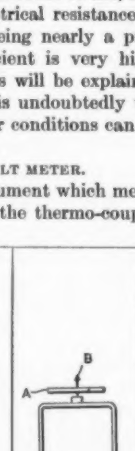


Fig. 5.—Coil of the pivoted type of pyrometer.

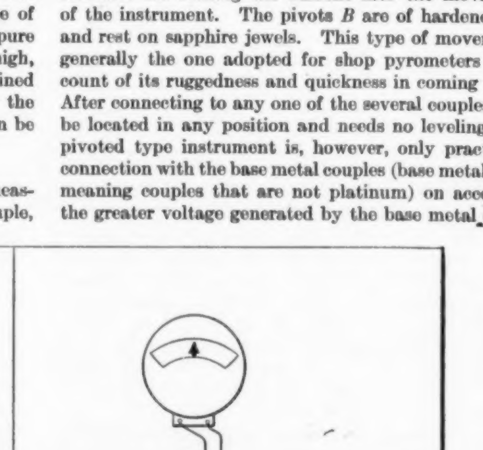


Fig. 6.—Diagram showing arrangement of double pole switches employed for the purpose of connecting several couples with one instrument.

* Courtesy of *Machinery*.

giving more power. At this point it may be well to mention that suspension instruments are termed high-resistance instruments, while pivoted instruments are termed low-resistance instruments. Suspension instruments generally have an internal resistance anywhere from 200 to 1,000 ohms, while the pivoted instrument has a resistance of only from 5 to 15 ohms. The effect of this difference in resistance will be discussed under the following heading:

LEADS AND SWITCHING DEVICES.

By leads is meant the wires that carry the current from the thermo-couple to the instrument. In all cases the length of lead that is supplied by the maker should never be cut or lengthened, except when used with the suspension type of instrument where the resistance is equal to 500 or 600 ohms as stamped on the scale of the instrument. In the case of an instrument having 500 or 600 ohms resistance, the addition of 200 or 300 feet of wire will not introduce any appreciable error. As an example, suppose we have a suspension instrument and that on its scale or on the certificate sent with it, it is stated that the instrument has a resistance of 500 ohms; and that the leads that were supplied are not long enough to reach to some solid foundation. We could safely add 200 feet of No. 14 B. & S. gage copper wire, because this wire has a resistance of only 0.005 ohm per foot double, which for 200 feet would be $200 \times 0.005 = 1$ ohm. This introduces an error in the reading of the pyrometer of only 0.2 per cent, which at 1,500 deg. Fahr. would mean that the instrument reads low by 3 deg. Fahr., and for shop use this would be a negligible error. On the other hand, with a low-resistance pivoted type of instrument having only 10 ohms resistance, if we should add 200 feet of No. 14 B. & S. copper wire having 1 ohm resistance, we would have an error of 10 per cent. At 1,500 deg. Fahr., that would equal an error of 150 degrees that the instrument would read low.

The above examples also hold for the length of thermo-couples used on the suspension instrument. It does not matter much whether the thermo-couple is shorter or longer than originally supplied with the instrument, but with a low-resistance instrument it is important that the thermo-couple be kept within 12 inches of the original length as supplied by the maker, for the reasons stated. In some makes of instruments called high-resistance, it is found that they have an internal resistance of only 100 ohms, or even less. It is, of course, evident that shortening or lengthening the leads will cause an appreciable error with an instrument of this class. Also, on an instrument having about 100 ohms resistance and using a platinum couple, it is important to expose the same length of couple to the heat at all times on account of the temperature coefficient of the couples before mentioned. Platinum, in common with all pure metals, changes its resistance with change of temperature, the change equaling approximately 0.002 ohm per degree per ohm, or it about doubles its resistance for every 500 deg. Fahr. rise in temperature. To illustrate how this may affect the accuracy of a so-called high-resistance instrument, the actual resistance of which is only 100 ohms, consider an instrument with 24 inches of couple exposed to the heat in the furnace, 12 inches of the platinum couple having a resistance of 0.5 ohm at room temperature. At 1,500 deg. Fahr. this resistance is increased to $1{,}500 \times 0.002 \times 0.5 = 1.5$ ohm. The instrument will read 1.5 per cent low at this temperature if its scale has been drawn, taking into account the heating of 12 inches of the couple. The base metal couple is practically a zero coefficient; therefore it can be heated any length.

SWITCHING DEVICES.

Several thermo-couples are often used with one instrument; therefore, some switching device must be used, which in most cases consists of a double pole switch or a rotary switch. Connections to double pole switches are made as shown in Fig. 6, while connection to a rotary switch is made as illustrated in Fig. 7. Switches should be kept clean and bright, and this is especially important on low-resistance systems. Where a furnace is so large that two or more thermo-couples are required, the double pole switch gives the best results on account of the fact that the rotary switch has one common point of connection to all thermo-couples and it is almost impossible to thoroughly insulate the thermo-couples, stray currents between the thermo-couples themselves being liable to cause a considerable error. The rotary switch is, however, more desirable than the double pole switch where two or more furnaces, each having one thermo-couple, are indicating one instrument, as it is possible to take readings faster and it shows at a glance which furnace is switched onto the instrument.

THE COLD END OF THE COUPLE.

The cold end is the name given to the points where the couple ends and the conducting wires are soldered on, B and C being the cold end of the couple shown in Fig. 1. The instrument, as already mentioned, measures in millivolts (0.001 volt) and its scale has been marked to indicate directly in degrees of temperature. The number of millivolts obtained from the couple depend upon the difference of the temperature between the junction A, Fig. 1, and the cold end B-C. For example, suppose the junction A is at a temperature of 1,500 deg. Fahr. and the cold end B-C has a room temperature of 75 deg. Fahr. The difference is 1,425 degrees, and assuming that we get 50 millivolts for this difference, where the 50 millivolt point should come on the scale we find marked 1,500 deg. Fahr., which is the correct temperature of the furnace, providing the instrument has been calibrated for a cold end temperature of 75 degrees. When the wire is disconnected from the instrument, the pointer should stand at 75 degrees, which is at the beginning of the scale. Should we now raise the temperature of the cold end to 100 deg Fahr., our difference between the hot end and cold end which was 1,425 degrees is now only 1,400 degrees, and the number of millivolts generated is less in direct proportion, causing the instrument to read only 1,475 deg. Fahr., while the furnace is still at 1,500 degrees, thus giving an error of 25 degrees that the instrument reads low. To conclusively demonstrate the correctness of the preceding explanation: should we heat the hot junction A and the cold end B-C to the same temperature we would get no indication on the instrument, because the temperature difference would be zero, which gives us no generated millivolts.

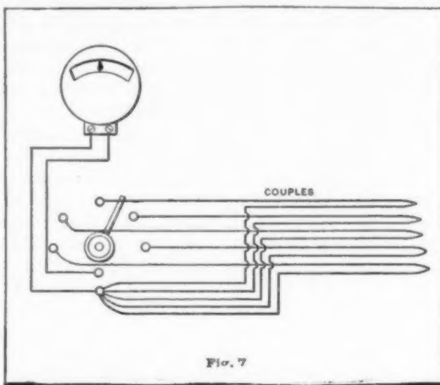


Fig. 7.—Diagram showing arrangement of rotary switch connecting several couples with one instrument.

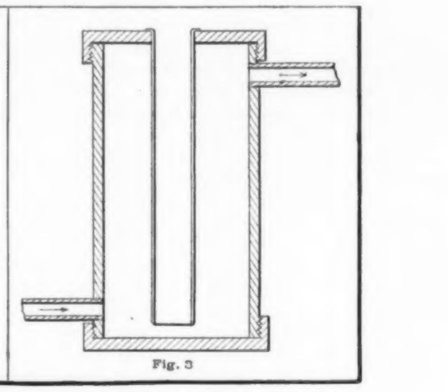


Fig. 8.—Cross-section of steam jacket for maintaining a constant cold-end temperature.

The high-resistance platinum couple instrument, known as the "Le Chatelier" pyrometer, is as a rule calibrated for a cold end temperature of 32 deg. Fahr., which is the temperature of melting ice. It can be readily seen by observing the scale of an instrument, at what point the cold end is to be kept. In the case of the high-resistance instrument just mentioned, the pointer comes to rest at 32 degrees, which is generally marked in small figures on the scale. In using this instrument for obtaining actual indications of temperature, it is necessary to provide a vessel containing a little water and chopped ice, and immerse the cold end in the ice water. The commercial shop instrument, or the low-resistance type, is generally calibrated for a cold end temperature of 75 deg. Fahr., it being assumed that 75 degrees is a fair average temperature in a shop; but in many cases it is found impracticable to go far enough away from the furnace with the cold end to obtain a uniform temperature of 75 degrees. Therefore, some means of keeping the cold end temperature constant is desirable. Many schemes for doing this have been tried, such as the use of water jackets and burying the cold end in the ground, which of course is all right if one is certain that the temperature does not vary greatly; but one of the surest ways of taking care of the cold end is to place it in boiling water, which can be done by using a chamber made from a pipe having a cap screwed on the top and bottom, and a copper well closed at one end extending down into this pipe. The outside pipe, as shown in Fig. 8, should have a small inlet and an outlet. Steam can now be connected to the lower pipe, which will condense inside of the chamber and very little of the steam will escape through the top pipe, thus maintaining a uniform cold end temperature of 212 deg. Fahr. Now, to adjust the instrument to correspond to this cold end temperature, all we have to do is to set the pointer at 212 degrees on the scale when the leads are disconnected. This is accomplished by a zero adjuster that is found on most instruments. If the instrument is not provided with a zero adjuster, the cover may be taken off, and on the movement there will be found a cross piece shown at A in Fig. 9, having a clip B on it to which the spring A, Fig. 5, is soldered. Holding this clip are one or two little screws shown at C in Fig. 9. To adjust the pointer to 212, loosen the two screws C and move clip B until the pointer stands at 212 deg. Fahr. Of course while doing this the leads to the instrument should be disconnected. If we now insert the cold end into the steam jacket, when steam is going through, the instrument will be correct as far as the cold end temperature is concerned, and will stay correct as long as the steam is flowing through the steam jacket.

METHODS OF LOCATING THE THERMO-COUPLE IN A FURNACE AND HOW IT SHOULD BE PROTECTED.

The base metal couple—the one that is best adapted for shop use—is generally made up of two wires having a diameter of about 1/8 inch, so that the couple is quite rugged. It is generally insulated by winding each one of the wires with asbestos thread and afterward painting it with some cement composed of alundum, or carborundum and silicate of soda. The couple, insulated as described, is then placed in a 3/8 inch iron pipe, which is supposed to go into the furnace. In most cases, however, and especially in the case of pyrometers used in high-temperature annealing furnaces, it is desirable to put one more thickness of pipe over the 3/8 inch pipe, as it gives a longer life to the thermo-couple; and when the temperature does not change very rapidly the couple is found to be sensitive enough. The couple should be mounted in the furnace either from the top or from the side, and it should not be near the source of heat, but should be placed in such a position that it receives the average heat. The thermo-couple should project into the furnace at least 6 inches, and if possible 10 inches, because there is a great amount of conduction along the pipes that form the protection of the couple, which would tend to make the temperatures indicated by the pyrometer too low, if the thermo-couple was not inserted in the furnace for at least this distance. After the thermo-couple has been used for some time, it should be examined to see if the wires are broken or bare of insulation. If the wires are broken close to the twisted and welded end, the couple may be cut off and scraped clean for an inch or two, twisted together again and

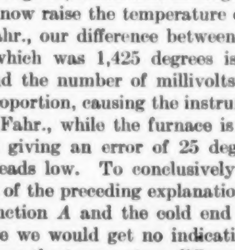


Fig. 9.—Adjustment on movement for setting for proper cold-end temperature.

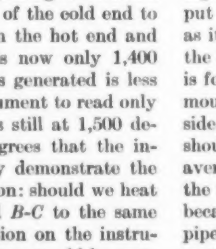


Fig. 10.—Method of checking "shop couple" against "standard couple."

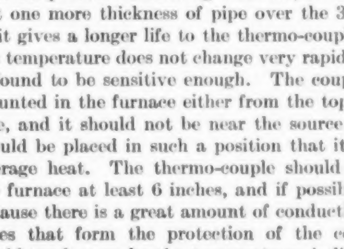


Fig. 11.—Diagram showing modification of pyrometer couple for obtaining the recalescence point of steel.

welded by means of the oxy-acetylene flame, or electric arc. Of course before welding the couple—should it be bare of insulation—it should first be wound with asbestos, as it will be found more convenient to wind the wires when they are apart than when they are welded together. Platinum couples may be welded very successfully in the electric arc, and in this way the life of the thermo-couple can be considerably lengthened, because as a rule the loss of 12 or 14 inches of the couple will not introduce any appreciable error.

METHODS OF CHECKING A PYROMETER IN THE SHOP.

A pyrometer, like any other instrument, must be frequently checked. In order to do this easily and with a fair degree of accuracy, it is desirable to have on hand one portable instrument that is used only for checking purposes. If such an instrument is at hand, the easiest way to check the shop pyrometer is to take the thermo-couple of the standard instrument and remove it from its pipe protection. Likewise with the pyrometer that is to be checked: remove its couple and protection from the furnace and remove the protection from the thermo-couple, and tie the standard couple and the couple that is to be tested together with asbestos thread, first insulating each with a small piece of asbestos paper at the tip. Fig. 10 shows the method of tying the couples together and protecting with asbestos paper. A small cast-iron pot or crucible with commercial lead can be used as the source of heat. The lead can be heated to a temperature of 1,500 or 1,600 deg. Fahr., and the couples having very little protection on them, are immersed in the lead but not allowed to touch the bottom of the pot. Under these conditions, the couples will very rapidly acquire the temperature of the molten lead; also being of the same cross-section, they will follow each other with a very slight temperature difference between the two. By observing the shop instrument on the test and the standard instrument, the difference in reading may be easily noted, which should be marked down in tabulated form for three points on the scale; and these records should be kept, as they show a history of the instrument, i. e., whether its error, if any, is constant or varies.

If the pyrometer installation is a small one and it would be too expensive to keep an instrument only for the purpose of checking, tests are made by using known melting points. Two points on the scale may be easily checked, as every metal when it solidifies keeps its temperature constant for an appreciable length of time—long enough so that one can easily determine the melting point by observing the pyrometer pointer. For instance, lead solidifies at 618 deg. Fahr., which forms our first checking point. Common table salt, or sodium chloride, solidifies at 1,440 deg. Fahr., approximately, and gives a fine high point for checking. Of course it is understood that the couple should be insulated with asbestos paper, as previously mentioned, and immersed directly into the lead, or salt, as the case may be. More refined methods could be mentioned, but it is impossible to make use of them outside of the laboratory with any degree of accuracy.

GENERAL POINTS TO BE OBSERVED IN THE USE OF THE PYROMETER.

The most common sources of error with pyrometers are, as a rule, found to be due to variations in the cold end temperature or to dirty contacts at the switches or binding posts, and special attention should be given to these three points to insure good results. Another common source of trouble is that the indicating instrument is hung up on the furnace where the temperature of the instrument sometimes is as high as 150 deg. Fahr., which is too hot for an electrical instrument; and no great accuracy can be expected under this condition. The moving copper coil of the instrument has a high temperature coefficient and its resistance changes appreciably with change of temperature, it being negligible for a few degrees, but rises of 50 or 75 degrees above room temperature—for which the instrument was calibrated—will cause a serious error. Also the phosphor-bronze control springs will fatigue when exposed to this high temperature, tending to make the instrument read low.

HOW TO OBTAIN THE RECALESCENCE POINT OF STEEL.

It is often desirable to find the recalescence point of steel. This can be done with a commercial indicating or recording pyrometer with a very slight modification of the thermo-couple, by taking the thermo-couple and reducing the tip of the junction, Fig. 11, for a length of about 1½ inch. Reducing it to a diameter of about 1/16 inch, winding it with asbestos and again re-welding the ends, will render the thermo-couple very sensitive to rapidly changing temperatures. A small sample of the steel of which the recalescence point is to be taken, has to have a hole drilled in it about 1 inch deep and large enough to take the reduced end of the couple. The thermo-couple is then inserted into the steel sample, and the sample is heated either in a small electric furnace or uniformly heated with a gas flame until the pyrometer shows a temperature of about 1,700 deg. Fahr. Without disturbing the couple, the sample and couple are removed from the fire and the sample allowed to cool. Readings on the pyrometer are now taken every 10 seconds, putting the readings down in one column for time and in another for temperature. The temperature as indicated by the pyrometer will be less for every 10-second reading, until the recalescence point occurs, when the temperature will remain constant for 20 or 30 seconds, and sometimes as long as 1 minute, depending on the size of the sample. This steady point is, of course, the recalescence point of the steel. If the absorption point is wanted, the temperature and time are taken every 10 seconds while heating the sample, although the absorption point will not stay steady as long on the pyrometer as the recalescence point. Of course if a recording instrument is at hand, simply by reducing the diameter of the couple as previously described, the recorder will record the absorption and recalescence points. If the sample is made ½ inch in diameter and 2 inches long, it is amply big for obtaining these points. The hole should not be too large, but the thermo-couple should fit rather snugly in it.

The Bacterial Flora of Trees and Men*

Some Characteristics of Bacilli That Have Been Little Studied

By Stephen J. Maher, M.D.

In the hope of making my subject interesting, I have taken advantage of the fact that the maker of the annual address in medicine is allowed some privileges of speculation and of order of statement that could not be desirable in strictly scientific discussion. Nevertheless, no deductions herein recorded are without bases of experimental support.

For the purpose of keeping the *motif* and nomenclature of this address clear and uninvolved, I wish you to consider all bacterial life as divided into spore-bearing bacilli, non-spore-bearing bacilli, cocci, and a fourth class to include yeasts, molds and the higher forms. As to this fourth class I will have very little to say to-day.

In the test tube when a spore-bearing bacillus reaches the limit of its power of vegetative growth, either because it has covered the surface of the hard medium on which it has been planted, or because it has produced a sufficient amount of toxins in liquid media to inhibit its further development, each little rod transforms itself into ovoidal or round shapes sometimes thicker than the original rods and sometimes less thick. These shapes, the spores, are the resting stage of the bacillus. They undergo no further change as they grow older except to thicken their outer capsule, and to become somewhat more resistant to such harmful influences as heat and acid. Of course, as soon as they are transplanted to a favorable environment they grow again into rod shapes and multiply as rods.

In Nature when the spore-bearing bacillus finds its life threatened by cold or by starvation, or by poisoning from its own secretion, it becomes a spore or two spores. When its environment is merely difficult, not threatening, the bacillus lengthens out into filaments or develops internal coccal granules.

The only spore-bearing bacilli that cause disease are the bacillus of anthrax and the bacillus of tetanus and the gas bacillus. Considerable attention has been everywhere paid to these three spore-bearing bacilli as well as to cocci and yeasts and non-spore-bearing bacilli, because they so frequently produce disease. But the harmless spore-bearing bacilli that we often drink with our milk and that we always eat with our salad, have received very scant attention indeed from medical textbooks, or medical teachers, or medical research workers. The argument for neglecting them is that no disease comes from them. My argument for the need of studying them is, that all germs that cause disease come from them. That is a pretty strong statement, but I hope to be able to stagger your incredulity without bewildering you with too many technical details. And if I succeed in convincing you, or even interesting you, I will give you a new power for grappling with many of the difficult problems of medicine and hygiene.

Where Spore-Bearers Exist Alone.—For the purpose of this address it is important to learn if there are any places in Nature where only spore-bearing bacilli grow. While on a mid-winter visit to a medical friend in the Adirondack Mountains some years ago, he and I debated the question: Is there any bacterial life in this cold mountain air? My friend's view and the belief of all the scientific men thereabouts was that this glorious dry air, 10 degrees to 50 degrees below zero, was germ free. To decide the matter we made many interesting experiments during the next week with the following results:

Spore-bearing bacilli in pure cultures grew on all petri plates of agar exposed out of doors before snowfalls, during snowfalls, or after snowfalls. Spore-bearing bacilli, pure except for an occasional mold from the thicker twigs, grew from the foliage of all the evergreen trees in the mountain forest, whether near to the village or distant. Of course, all the technique of getting the leaves was as careful as alcohol lamps, sterile jars, and freshly flamed instruments could make it.

I have repeatedly exposed agar plates to outdoor air in New Haven in Winter and in Summer. After rain storms in Summer and after snow storms in Winter, and sometimes during snow storms in Winter, the incubated plates have yielded only columns of spore-bearing bacilli. At all other times outdoors, and at all times indoors, the colonies of spore-bearing bacilli have been mixed with colonies of various kinds of cocci, non-spore-bearing bacilli, and molds. Plantings of blades of grass have invariably given me only pure cultures of spore-bearing bacilli, provided the blades were secured a few yards from the road.

At my request, Dr. P. M. Carrington, of the United States Public Health Service, sent to me from Fort Stanton, New Mexico, a splendid assortment of the foliage of the grasses and stunted trees that grow with some difficulty on the dry plateau, on which the national reservation is situated. The collection included specimens of alfalfa, loco-weed, scrub oak, cedar, salt-grass, blue-grass, blue gramma-grass, cottonwood and holly. The specimens were gathered with sterile instruments and expressed to me in sterile sealed tubes. From all of the grasses and foliage, only spore-bearing bacilli of various kinds grew. From the roots of several of the grasses to which bits of soil adhered, colonies of cocci grew in greater numbers than colonies of spore bacilli. Plantings of various kinds of sea grasses growing on the shores of both sides of Long Island Sound, gave only spore-bearing bacilli if the specimens were gathered from clean rock or sand, and gave admixtures of coccal colonies if the specimens came from plants that were muddied or that were submerged at high tide. Some beautiful specimens, gathered on the Long Island shore at a spot where they grew always under water on a clean white beach, gave only pure cultures of spore-bearing bacilli.

Where Spore-Bearing Bacilli Are Not Found.—For the purpose of my argument it is also important to know whether there are places in Nature entirely free of spore-bearing bacilli. I intend to claim now that there are such places. Of course, I admit immediately that in most places of the earth there is a mixture of spore-bearing bacilli and the other forms of bacterial life. These mixtures occur in the soil, in water, in all decaying vegetable matter, in milk and other exposed albuminous or sweet fluids, in street dust and in house dust.

Where, then, are they not found? During the past twenty years I have examined, microscopically, many thousand specimens of human sputum. Except in the cases of a few patients who were sleeping out of doors among pines and firs in the coldest week of an Adirondack Winter, I have never found spores in a specimen of sputum. Strange to say—and important to note—in one batch of specimens raised by these pine-wood patients after the coldest night of the year, when the temperature had been between 40 and 50 degrees below zero, I was able to grow from two specimens, a spore-bearing bacillus of the same general character as the spore-bearing bacillus that grew from the green needles on the neighboring trees. And, occasionally, in cases of chronic bronchitis I have grown from the sputum a large yeastoid bacillus, having many of the cultural characteristics of *Bacillus anthracis*. I have never seen a case of "wool sorter's disease." Of course, in that disease, *Bacillus anthracis* is found in the air passages. But with these exceptions, I have never seen a spore in human sputum, tuberculous or not, and, in spite of many hundreds of cultures made from all kinds of human sputum, I have never been able to grow from sputum spore-bearing bacilli in any kind of culture media, solid or fluid.

My experience, therefore, and it has been considerable, seems to justify me in saying that spore-bearing bacilli are not found in the healthy human air passages, and only very exceptionally found in diseased air passages.

*Presidential Address to the Connecticut State Medical Society.

No Spore-Bearing Bacilli on Healthy Human Skin.—During the last fifteen years I have had occasion to make bacterial cultures from various parts of the body, from all sorts of people. I have never been able to find a spore-bearing bacillus on the surface of the skin nor to grow any spore-bearers from the skin, from cerumen, from smegma, from the oral or nasal mucous membrane, nor—and I say this with hesitation—from the human hair. In the food tract, however, the spore-bearers persist, and they can be easily grown from the contents of the bowels.

The facility with which cultures of cocci can be made from the skin and the mucous membranes of the upper air passages, and from sputum and from purulent discharges of all kinds, makes this absence of all spore-bearing bacilli from the human skin worthy of attention. Certainly every wind that blows, whether dust-laden or not, sprinkles the human skin with spore-bacilli. What happens to these hardiest of bacteria that are continually deposited on the human skin? Of course, bacterial forms, other than cocci, are found on the human skin and in human sputum in health and in disease, but even they fit readily into the theory that they came originally from the spore-bearing bacilli. These are the diptheroid and the acid-fast bacilli that are found in smegma and cerumen, in the accumulated oily sweat of arm-pits and groins, and in ozenal crusts. They are evidently transition forms; they do not preserve their acid-fast character, and frequently not their bacillary form on subculture. Very instructive also are the bacteria I have found in severe cases of chronic psoriasis. Some of them were perfectly acid-fast and resembled thick granular tubercle bacilli, but like some of the growths in smegma, they varied in acid resistance. Some of the rods had none at all, and mixed with them were cocci of the same size and staining as the coccal granules in the bacilli. Attempts at culturing these psoriasis bacteria resulted only in growths of cocci.

Now, it was only at last year's meeting of this society that I exhibited pure cultures of acid-fast bacilli simulating tubercle bacilli, that I developed from old acid-fast spores of the hay bacillus—*Bacillus subtilis*. And, in the hair the bacteria that I have found have been diphtheroid bacilli and cocci, sometimes in short chains.

Of course, I don't even insinuate that the partly acid-fast bacilli cause psoriasis any more than I would claim that smegma bacilli cause smegma, or that the acid-fasts of the only secretion of an axilla caused the oily secretion. The simple explanation is that the cells of the skin, though increased in number, were so weakened with disease that they could not finish the breaking up of the bacilli or their spores, and the bacilli and spores therefore grew on the skin in this transitional form.

That the smegma bacillus may have an importance not usually ascribed to it, I have indicated in a little paper published by the *Lancet* in November, 1913, in which I told of a case of pulmonary tuberculosis following an infection by smegma bacilli. The histories of women patients at the State tuberculosis sanatoria reveal a surprisingly large number of cases of consumption, whose first symptoms were in the uterus, the tubes or the ovaries.

I have noted that it is with hesitation that I speak of the human hair as being free from spore-bearing bacilli. I can only say that such has been the result of my experiments, but my experiments have been too few and have been mostly with tuberculous patients, and I do not feel that I have the same right to speak with certainty on this matter as I have concerning the flora of the air passages and the skin. But, even if further experiment only shows that very rarely are spore-bearing bacilli found in the hair, what a tremendous digesting or transforming power the hair must have! And the cells of the intact human skin, and the mucous membrane of the air passages, do they digest or transform the spore-bearing bacilli? Or are the cocci that abound on skin the result of an action similar to Pfeiffer's reaction in which cholera vibrous and typhoid bacilli are transformed into coccal forms in the peritoneal fluid of injected guinea pigs?

Can Bacteria Change Form?—Because this is an annual address and is, therefore, protected from the critical discussion that perhaps many of my hearers feel it deserves, I will abstain from going deeply into this fascinating subject of the varying morphology of bacteria. But at least I may refer to my papers on this subject before the International Tuberculosis Conferences of Philadelphia, Brussels, (*Medical Record*, November 12th, 1910), and Berlin (*Medical Record*, December 27th, 1913), in which I tell first, of breaking up spores of the subtilis into cocci by culturing them in various strengths of salt water, and, second, of forcing even tubercle bacilli to elongate, become granular, and, finally, extrude these granules as culturable cocci.

I must be permitted also to refer to Much's demonstration of a coccal prebacillary form of the tubercle bacillus, to Noguchi's making bacillus bifidus alternately spore-bearing and non-spore-bearing by changing its culturable environment. Of course, it is very remarkable to note the fixed characters that so many of the bacterial cultures in our laboratories preserve, and it is pleasant and restful to think that in Nature they also always retain these characters, but the conditions in the laboratory test tube, and the conditions in Nature are widely different. In the test tube the bacillus grows within a carefully regulated temperature range on a specially favored medium from which all other bacterial life has been rigidly excluded. In Nature, it is needless to say, these conditions are impossible to find. Every breeze that blows makes a hopeless mixing of the bacterial forms within its reach, and changes the gaseous environment even of those forms that it does not move.

Is the Subject Important?—Perhaps you feel like asking where does all this lead to? What difference does it make to the Connecticut Medical Society whether or not the harmless spore-bearing bacillus is the only form of bacterial life in the clean places of the earth? What difference does it make to us that there are to be found no innocent spore-bearing bacilli on our skin or in our lungs? What difference does it make to us whether the spore-bearing bacilli that we inhale or that fall on our skin, die of fright and melt away, or are broken up into cocci by our defensive epithelium? What difference does it make to us whether smegma bacilli come from *Bacillus subtilis* or not; or whether smegma bacilli may become pathogenic, and, after some period of incubation in the cells of the human being, acquire the power to cause tuberculosis in the lungs or elsewhere?

Well, you will find your own answer to some of these questions if you take stock for a moment of what your present bacterial faith is. Is it not this? "The unicellular vegetable organisms called bacteria consist of many thousands of species, some harmless to man and some harmful. These species, like the species of fish that swim in the sea, are distinct in character and origin. The staphylococcus must have come from another staphylococcus, the streptococcus from another streptococcus, the diphtheria bacillus from another diphtheria bacillus, the plague bacillus from another plague bacillus, the tubercle bacillus from another tubercle bacillus, and so on to the end."

It is on this conception of the origin of bacteria that all modern hygienic efforts are based. It is because of this conception of bacterial life that so many enthusiastic tuberculosis workers promise, by segregation, to rid their communities of the disease within a specified number of years, sometimes ten, sometimes fifty. But what becomes of your old faith if the innocent *Bacillus subtilis* may, on greasy human skin, become the harmless smegma bacillus, and if the harmless smegma bacillus may learn to live in human cells and later to destroy them and cause tuberculosis?

How false is the hope you give to the public about eradicating tuberculosis if you bend all your energies and theirs toward isolating the sick. Of course, the most stupid fruit dealer knows that he must remove the spoiled apples in a barrel in order to save the others. But the real apple problem, as our Mr. Hale and the other scientific orchardists have shown, is to learn how to grow and market all our apples sound.

Ten years ago, when I began to claim that by changing the degree of saltiness or sweetness of culture media, I could profoundly alter the characteristics of various bacteria, it was difficult to get a hearing, but now, no such difficulty is encountered. The general principle is accepted and forms the incentive of research work everywhere. To-day, however, I want to keep your attention fixed on conditions that exist in Nature, not on those of the laboratory. And, to return to the problem of the disappearance of spore-bearing bacilli from the human skin, it ought in fairness to be said that the text-book explanation of this disappearance would be that as the spore-bearing bacilli did not find a suitable environment on the skin or in the throat or lungs, they died promptly and vanished. This explanation will not hold because spore-bearing bacilli are the most resistant germs of which we have knowledge, and, because if they did die, they could not vanish unless you attribute a tremendous digestive power to the superficial epithelial cells. And, if you concede such a faculty to these cells, you make simple the other explanation that these cells dissolve the shell of the spore-bearing bacilli and release as cocci their contained vital granules.

If this possibility be granted, it makes doubly interesting the recent researches showing that tuberculosis is a family disease. The tubercle bacillus is very sensitive to its environment. I have some strains that formerly grew well on glycerin-agar and on blood serum but after growing luxuriantly for one or more years on glycerin broth-potato, they cannot now be induced to grow in their former favorite media of glycerin-agar or blood serum. It is easy to understand, therefore, that the tubercle bacilli that have been evolved from smegma bacilli in a father or mother after long struggles with the weakening lytic power of that father's or mother's cells, would be much more dangerous to the children of that father or mother, than to the children of any other father or mother, even though living in the same intimacy.

Such a theory would also explain the surprising immunity of so many husbands and wives of consumptives. At the New England Conference on Tuberculosis last October, I asked whether any of the distinguished authorities present knew of a case in which they had been convinced from personal investigation that a negro man or woman had taken tuberculosis from a white man or woman; or, of a case of a white man or woman that had taken tuberculosis from a negro man or woman; or, of a case in which a parent had taken tuberculosis from its young child. There was considerable surprise at the asking of the question, but there were no affirmative answers. I don't say that such cases may not occur, but I know of none and I think they must be very rare.

The Origin of the Pneumococcus.—Let us go back to the always-present cocci of the skin and air passages: if they are derived from the harmless spore-bearing bacilli of the air and leaves, is it not easy to understand why they are harmless on the intact skin, but become harmful when they have lived for a few generations, or seventy-two hours, in the broken cells and effused blood of an injured arm or leg? And, does not this conception afford a new and inviting lead into the mysterious problem of pneumonia—traumatic pneumonia, epidemic pneumonia, and tuberculous pneumonia? For what is the cause of pneumonia? It's usually a coccus that is found frequently in the mouth vegetating harmlessly, but that from the beginning to the end of cold weather is our most dangerous foe.

In warm weather, the atmospheric conditions are so favorable that the spore-bearing bacillus grows readily in Nature in its bacillary form, and, when taken into the air passages, it is easily and quickly broken into its coccal granules. These resulting cocci inherit from their mother rod only a very thin shell which is easily dissolved by the cells and fluids of the air passages. They are incapable of penetrating even the weakest epithelium. In Summer, men have injuries to the chest; they get chilled in the water of the river or ocean, but, unless they are very old or have tuberculosis, they seldom have pneumonia.

Now, what happens in Winter in the pneumonia months? The spore-bearing bacilli of the street dust, and even of the bare trees, have long ago lost their vegetative bacillary form and have all turned to spores, and the capsules of these spores have become thicker and more resistant and often acid-fast. When the snow is on them, no matter how cold the weather is, there is little pneumonia in the community, but, if the streets and the fields are bare and the weather cold, and the winds high; in other words, if it is a green Christmas, the hardy spores of subtilis or some of its kindred spore-bearers are in haled with every breath by young and old. The cells and secretions of the air passages break up the spores as they did the rods in the Summer, but the resulting cocci inherit now a thick capsule like the shell of the tubercle bacillus, and this is not easily dissolved even by the most vigorous epithelium. And, in the weak and the aged and even in the young and strong who have by exposure, or by over-heating, or over-drinking, or excesses of any kind, caused a little congestion of the blood vessels of the air passages, these capsuled cocci gain access to the circulation and in a few hours there is another case of pneumonia.

In tuberculous pneumonia the development of the acute process may be explained in the same way except that the pneumococcus could come from the disintegrating tubercle bacillus. A few Winters ago I had a very severe epidemic of pneumonia in the Home for the Aged in New Haven. Every day for a couple of weeks, on the women's side of the institution, one or two new cases of pneumonia broke out. And the cases were very severe. And all this while there were no cases of pneumonia on the men's side of the institution. At about the tenth day, I discovered that one fussy old lady who coughed, but said she was not sick, had a chronic tuberculous process of the lungs. It was against the rule of the institution to harbor tuberculous patients. She was isolated, and, after a few days, sent home. Not another case of pneumonia occurred. We found then that all the first cases were the women who were her chums, or who sat with her at table, or who slept beside her in the dormitory. Her sputum injected into a rabbit killed it promptly and filled its blood with pneumococci. She, herself, died in a few weeks rather suddenly.

A Tree and a Man.—In conclusion, in order to visualize quickly some of the points I have tried to make in this address, imagine what would happen to a young germ-free man and a young germ-free tree suddenly placed on the germ-free soil of a mountain top. The winds from the neighboring mountains or valleys would sprinkle both the man and the tree with spore-bearing bacilli. On the tree these spore-bearing bacilli would continue to grow as spore-bearing bacilli. On the skin of the man they would be promptly changed to cocci. Both tree and man would thrive. The leaves that fell to the ground would die. The spore-bearing bacilli would at first become spores. As the leaves accumulated the tendency to spore formation would slacken and soon, in the moist center of the heaps of leaves, only granular,

non-spore-bearing bacilli would be found. As the leaves were ground into the soil, and the conflict between the tendency to spore formation and the tendency to normal vegetation became acute, the leaves would give off to the soil various kinds of cocci, and in places where the soggy earth covered some of the leaves and prevented access of air, some of the bacilli would be found that grew as rods, but with unripe spores at one end. These would be dangerous for the man for they would be the bacilli of tetanus. But, like all the other derivatives of the original spore-bearing bacilli, they would be of benefit to the soil of the mountain top.

On the man the coccal forms would help in the exfoliation of the dead cells of his skin and mucous surfaces. They would pass into his food tract, produce acid, and assist in breaking up difficult food in his intestines. If the young man took no care to remove from his skin the matter that gathered there as the result of perspiration, there would appear in many parts of his skin, particularly on those parts where the exudation was heaviest and most oily, in addition to the always-present cocci, many short granular rods of which a certain proportion would be acid-fast, and would look like tubercle bacilli.

Lightning and Lightning Rods

As soon as Benjamin Franklin demonstrated, by means of his famous kite experiment, the identity between lightning and electricity, the idea occurred to him (and doubtless simultaneously to others) of protecting buildings against destruction by lightning by providing them with electrical conductors that would convey the electricity to the ground without permitting it to harm the buildings themselves. The earliest view appears to have been to provide something that the lightning would strike in preference to the building itself; and the only essentials, from that point of view, appeared to be to have a conductor that was higher than the building, large enough in cross-section to carry the electrical discharge without melting, and well enough grounded to provide the electric current with an easy means of escape into the earth.

It was at a later date, if we remember correctly, that the idea occurred to those interested in this subject to make the lightning rod very sharp at the tip in order to take advantage of the well-known discharging power of points. The theory underlying this view was that the electrified cloud overhead would cause the earth where the building stands to be charged to a considerable potential, and that the lightning rod would cause the electricity thus resident in the ground to be silently discharged into the air, toward the cloud. According to this view of the function of lightning rods, a rod fails to play its part properly if it is actually *struck* by lightning. Such an occurrence would show that the rod had not been as effective in discharging the earth-charge as it should have been. There is no doubt that this view has elements of truth in it, because a well-grounded rod with a sharp point would certainly discharge a considerable amount of electricity. This fact is well illustrated by the glow that is sometimes seen at night at the tips of the spars and masts of ships, and which is known to the mariner as "St. Elmo's fire." This same phenomenon is also occasionally seen on the twigs of trees, and it is due to the "silent discharge" of electricity from these points. It is expecting a good deal of a single lightning rod, however, or of two or three lightning rods near together, to look to them to discharge in this way any very large fraction of the induced electricity that resides on the surface of the earth beneath a low lightning cloud that is powerfully charged. In cities where there are a great many metal roofs, pipes, cornices, and the like, and where steel is extensively used in construction, the aggregate "silent discharge" that occurs may not be very great, even when there are no rods present; and this explains why lightning seldom strikes buildings in large cities, where the height of the structures would seem to specially invite the stroke.

About thirty years ago Sir Oliver Lodge made an important contribution to the theory of lightning, and Prof. Henry A. Rowland shortly afterward gave his attention to the subject also. The views of these men, and of others following along the same line, have profoundly modified our conception of the lightning rod problem, and we may therefore advantageously give a brief account of them. A steady electrical current flows through a conductor in such a way that every part of the cross-section of the conductor carries its own proportionate amount of current. When the current is variable, however, this is no longer true, and the parts of the conductor that are nearest the surface then carry more than their proportionate share of the current. If the changes in the current are slow, the distribution of the electricity through the conductor will not differ materially from that which prevails in cases of steady current; but if the changes are exceedingly rapid, the flow of electricity may be practically all confined to a film of the conductor lying very near the surface, the deeper layers of the conductor then having no electrical part to play, whatever. Lightning discharges are often of an oscillating nature, with very high frequency; and even if they are not *always* oscillatory, they are nevertheless so sudden that they penetrate the conductor only to a very slight depth. It is therefore plain that a lightning conductor, to be really effective in conveying a lightning discharge to the ground, should have as large a *surface* as possible, in proportion to its cross-section. The first thing to suggest itself, therefore, is to make the conductor in the form of a flat ribbon, which will have much more surface than a circular conductor of equal cross-section. Rowland has shown, however, that a sudden rush of electricity flowing through a ribbon-shaped conductor distributes itself largely along the *edges* of the ribbon, and therefore this form does not have the advantage that it at first appears to have, because the shape makes it impossible for the discharge to utilize all the surface. The most approved practice, to-day, consists in using bundles of small wires as conductors—twisting them together in such a way that the whole has somewhat the appearance of a wire rope, except that the twisting is done so that the structure of the rope is as open as possible, instead of being close, as in a rope that is to be used for hoisting or for traction. In one specimen of this kind that lies before us as we write, the conductor is built of thirty copper wires, each 0.0425 inch in diameter. In the center there is a core composed of six wires braided together, and around this are wound six strands, each composed of four wires that are braided together. The whole has a very open appearance, and the ether that constitutes so important a part in the mechanism of the electric discharge can come into immediate contact with the constituent wires at nearly all points. A conductor constructed in this way has about five and a half times the surface that it would have if it were made all in one piece, and had a circular section.

Copper is the best material for the conductor, and is far superior to iron. The electrical resistance of iron is something like seven times that of copper, and the depth of the superficial layer in which the sudden discharge mainly occurs is about ten times as great in copper as in iron. Therefore, on the whole, a copper conductor is seventy times as efficient, in taking care of a lightning discharge, as an iron conductor of the same size and shape.

In protecting a building against lightning it is desirable to inclose it in a sort of cage of electrical conductors of the kind described. By this we do not mean that the building should everywhere be covered by lightning conductors, but that a conductor should proceed down and along every prominent corner of the building, and along every sharp edge where the electrical potential of the building might be considerable.

The rods should be sharp at their points, in order to take advantage of the power of such points to discharge static electricity silently, and the points should be constructed of material that will resist the corrosive action of the weather. There is no need of using insulators to prevent the conductors from coming in contact with the building, but on the contrary it is better to secure them to the building by metallic fastenings, and to put them in good electrical connection with metal roofs. Gun-metal supports, fastened to the building by screws of copper or brass, are recommended. The conductors should be well grounded, the best form of ground consisting in a copper plate an eighth of an inch thick and at least three feet square, buried in moist earth near the foot of the rod. It is important to have the ground as near as possible to the foot of the rod, and nearness of the ground is probably more important than wetness of the soil into which the rod penetrates.

It is best to make each rod continuous from end to end, and if it is necessary for any reason to splice such a rod, the two parts should be connected with special care. When using a twisted or braided conductor such as we have described above, each wire of one section should be carefully soldered to the corresponding wire of the next section; and whatever the style of the rod may be, the two ends that come together should be united in such a way that the electrical continuity of the parts will be preserved. Lightning rods of galvanized iron are often seen, in which the ends abut with little or no attempt at securing good electrical conductivity—a collar being merely slipped over the ends in such a way as to keep them in the same straight line. The electrical resistance of a joint of this kind is vastly greater than that of the rod itself, and at a connection such as this the lightning may leave the rod and enter the building, even when the rod would be adequate to take care of the discharge if the electrical connection of its parts were proper.

Thus far we have touched only upon the electrical features of lightning rods, but a few words should also be said about their mechanical features. Lightning rods are often put up in a very unworkmanlike fashion, and high rods are frequently seen that are supported so poorly that they are in imminent danger of falling and causing injury to persons on the ground below. The support of the rod should always receive careful attention, and its adequacy should be tested from time to time.—*The Travelers Standard.*

SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

SATURDAY, SEPTEMBER 4th, 1915

Published weekly by Munn & Company, Incorporated

Charles Allen Munn, President; Frederick Converse Beach, Secretary; Orson D. Munn, Treasurer all at 233 Broadway, New York

Entered at Post Office of New York, N. Y., as Second Class Matter

The Scientific American Publications

Scientific American Supplement (established 1876) per year $5.00
Scientific American (established 1845) . . . . " 3.00

The combined subscription rates and rates to foreign countries, including Canada, will be furnished upon application

Remit by postal or express money order, bank draft or check

Munn & Co., Inc., 233 Broadway, New York

The purpose of the Supplement is to publish the more important announcements of distinguished technologists, to digest significant articles that appear in European publications, and altogether to reflect the most advanced thought in science and industry throughout the world.

Back Numbers of the Scientific American Supplement

SUPPLEMENTS bearing a date earlier than January 3rd, 1914, can be supplied by the H. W. Wilson Company, 39 Mamaroneck Avenue, White Plains, N. Y. Please order such back numbers from the Wilson Company. Supplements for January 3rd, 1914, and subsequent issues can be supplied at 10 cents each by Munn & Co., Inc., 233 Broadway, New York.

Table of Contents

r 4, 1915

Lightning
e fashion,
supported
of falling
low. The
ful atten-
n time to

CAN

15
rated
rse Beach,

ass Matter

year $5.00
" 3.00
countries,
tion
or check
ew York

publish
distin-
ant arti-
ons, and
thought
world.

ican

January
son Com-
s, N. Y.
son Com-
nd subse-
by Munn

are in a
y branch
composed
ts, thor-
atent ap-
e of the
technical,
rld, who
mark ap-
e United

,
way,
rk, N. Y.